NASA-CR-183931

TWR-18895

SPACE SHUTTLE

Solid Rocket Motors
Thiokol Corporation

Qualification of the RSRM Field Joint CF Case-to-Insulation Bondline Inspection Using the Thiokol Corporation Ultrasonic RSRM Bondline Inspection System

Final Test Report

March 1990

Contract No.	NAS8-30490
DR No.	5-3
WBS No.	4B102-10-10
ECS No.	SS2412

Thiokol CORPORATION
SPACE OPERATIONS

P.O. Box 707, Brigham City, UT 84302-0707 (801) 863-3511

(NASA-CR-183931) QUALIFICATION OF THE RSRM FIELD JOINT CF CASE-TO-INSULATION BONDLINE INSPECTION USING THE THIOKOL CORPORATION ULTRASONIC RSRM BONDLINE INSPECTION SYSTEM Final Report (Thiokol Corp.) 45 p CSCL 11A G3/37
Unclas 0279794

Thiokol CORPORATION
SPACE OPERATIONS

TWR-18895

Qualification of the RSRM Field Joint Capture Feature
Case-to-Insulation Bondline Inspection
Using the Thiokol Corporation Ultrasonic
RSRM Bondline Inspection System
Final Test Report

ORIGINAL CONTAINS
COLOR ILLUSTRATIONS

Prepared by:

(5 March 90)

Test Planning and Reports
Systems Engineer

Approved by:

Requirements Manager

Design Engineer

Program Management

Program Management

System Integration Engineer

3 15-90
System Safety

13 March 90
Reliability

3-20-90
Data Management
ECS No. SS2412

ABSTRACT

Qualification testing of Combustion Engineering's AMDATA Intraspect/98 Data Acquisition and Imaging System that applies to the redesigned solid rocket motor field joint capture feature case-to-insulation bondline inspection was performed on 29 Jan 1990. Testing was performed at M-111, the Thiokol Corporation Inert Parts Preparation Building. The purpose of the inspection is to verify the integrity of the capture feature area case-to-insulation bondline.

The capture feature scanner was calibrated over an intentional 1.0 by 1.0-in. case-to-insulation unbond. The capture feature scanner was then used to scan 60 deg of a capture feature field joint. Calibration of the capture feature scanner was then rechecked over the intentional unbond to ensure that the calibration settings did not change during the case scan. This procedure was successfully performed five times to qualify the unbond detection capability of the capture feature scanner.

The capture feature scanner qualified in this test contains many points of mechanical instability that can effect the overall ultrasonic signal response. A new generation scanner, designated the sigma scanner, should be implemented to replace the current configuration scanner. The sigma scanner eliminates the unstable connection points of the current scanner and has additional inspection capabilities.

CONTENTS

FIGURES

FIGURES (Cont)

ACRONYMS

CF	capture feature
KSC	Kennedy Space Center
RF	radio frequency
RSRM	redesigned solid rocket motor
URBIS	ultrasonic redesigned solid rocket motor bondline inspection system

1
INTRODUCTION

This report presents the procedures, performance, and results of the qualification test for Combustion Engineering's AMDATA Intraspect/98 Data Acquisition and Imaging System that apply to the redesigned solid rocket motor (RSRM) field joint capture feature (CF) case-to-insulation bondline inspection. The purpose of the inspection is to verify the integrity of the CF area case-to-insulation bondline. The inspection is performed at Thiokol Corporation's Wasatch (Utah) Space Operations facility and again at Kennedy Space Center (KSC). The Intraspect/98 system is referred to as the Thiokol Corporation Ultrasonic RSRM Bondline Inspection System (URBIS) (C77-0479).

Testing was conducted in accordance with CTP-0085, Qualification Plan for the Ultrasonic Inspection of the RSRM Field Joint Capture Feature Case/Insulation Bondline Utilizing the Thiokol Corporation Ultrasonic RSRM Bondline Inspection System. Testing was performed on 29 Jan 1990 at M-111, Thiokol's Inert Parts Preparation Building.

The URBIS functions by transmitting ultrasonic signals (pulse-echo) from the transducer surface to the case surface through a liquid couplant. A return signal is then received by the transducer. The return signal is then amplified, filtered, digitized, and processed for display. During an inspection, a well-bonded case-to-insulation interface will reflect a small signal, while an air-backed unbonded region will reflect a larger signal.

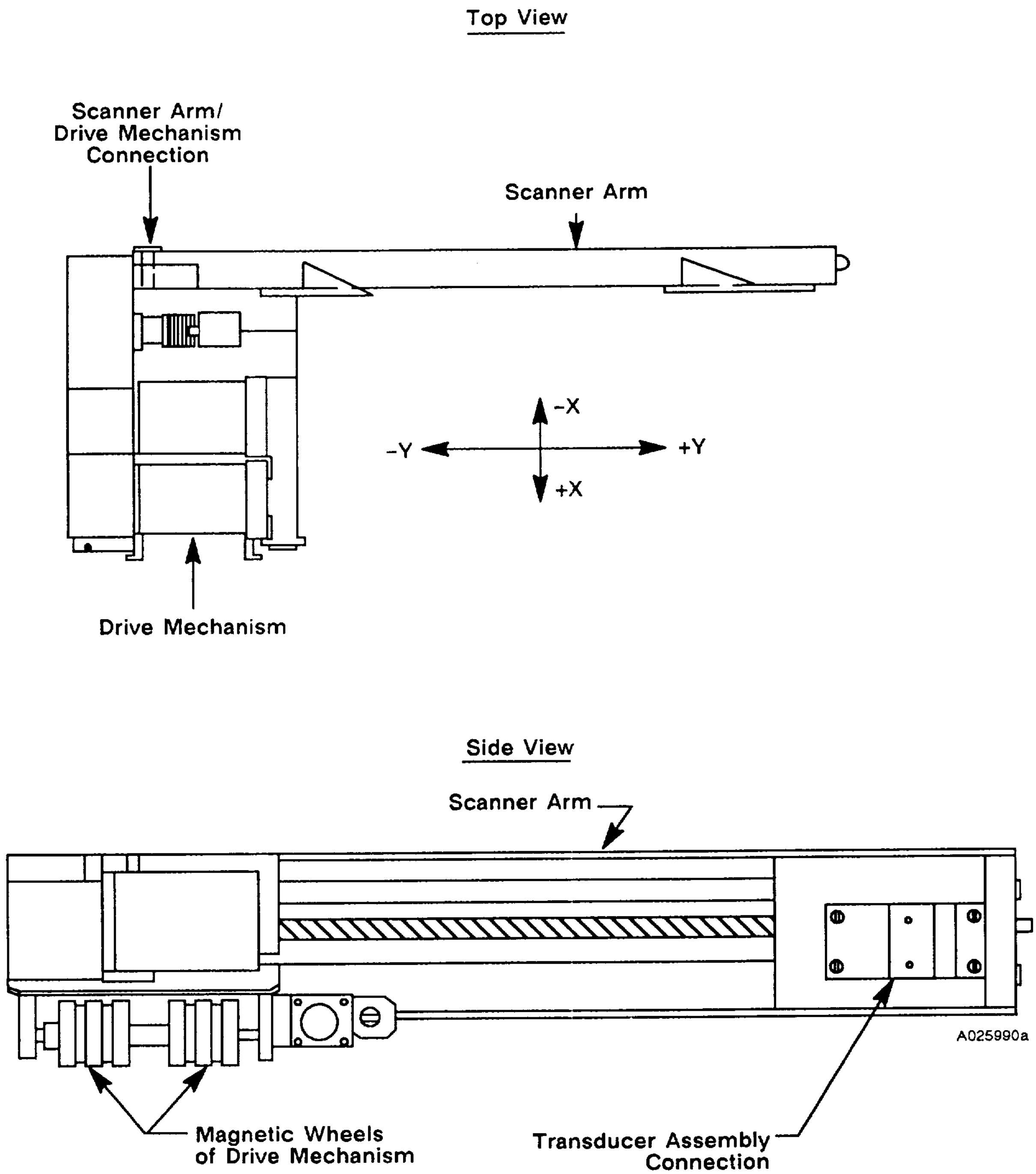
Qualification testing of the URBIS components that are generic to all inspections (CF, clevis, pinholes, and membrane) has been performed under CTP-0100 and is documented in TWR-18894. It is recommended that these documents and CTP-0085 be referred to for additional explanation of URBIS components and test procedures.

1.1 TEST ARTICLE DESCRIPTION

The CF scanner consists of a transducer assembly and the AMAPS 2090 scanner (scanner arm and drive mechanism). An ultrasonic transducer is positioned and held in place within the transducer assembly. The 0.50-in.-diameter broad band transducer has a center frequency of 2.25 MHz. Couplant feeder ports are integrated directly into the transducer assembly to provide a conductive interface between the transducer and the RSRM case. The transducer is coil spring- and leaf spring-loaded within the nylon transducer assembly (Figures 1 and 2). The CF scanner is part of the Thiokol Corporation Ultrasonic RSRM Bondline Inspection System (URBIS) (C77-0479). The URBIS was assembled under 2U129431.

Testing was performed on the RSRM Flight 13A aft center insulated segment (1U76667-01, S/N 0000030). A calibration standard consisting of a section of RSRM case (tang area) with intentional case-to-insulation unbonds was used to calibrate the CF scanner/URBIS. The calibration standard was assembled under 2U129702 and is shown in Figure 3.

A detailed configuration of the generic URBIS components (AMDATA Intraspect/98 Data Acquisition and Imaging System) used in association with the URBIS CF case-to-insulation bondline inspection qualification is documented in CTP-0100.



Note: Not to scale

Figure 1. CF Scanner (without transducer assembly)

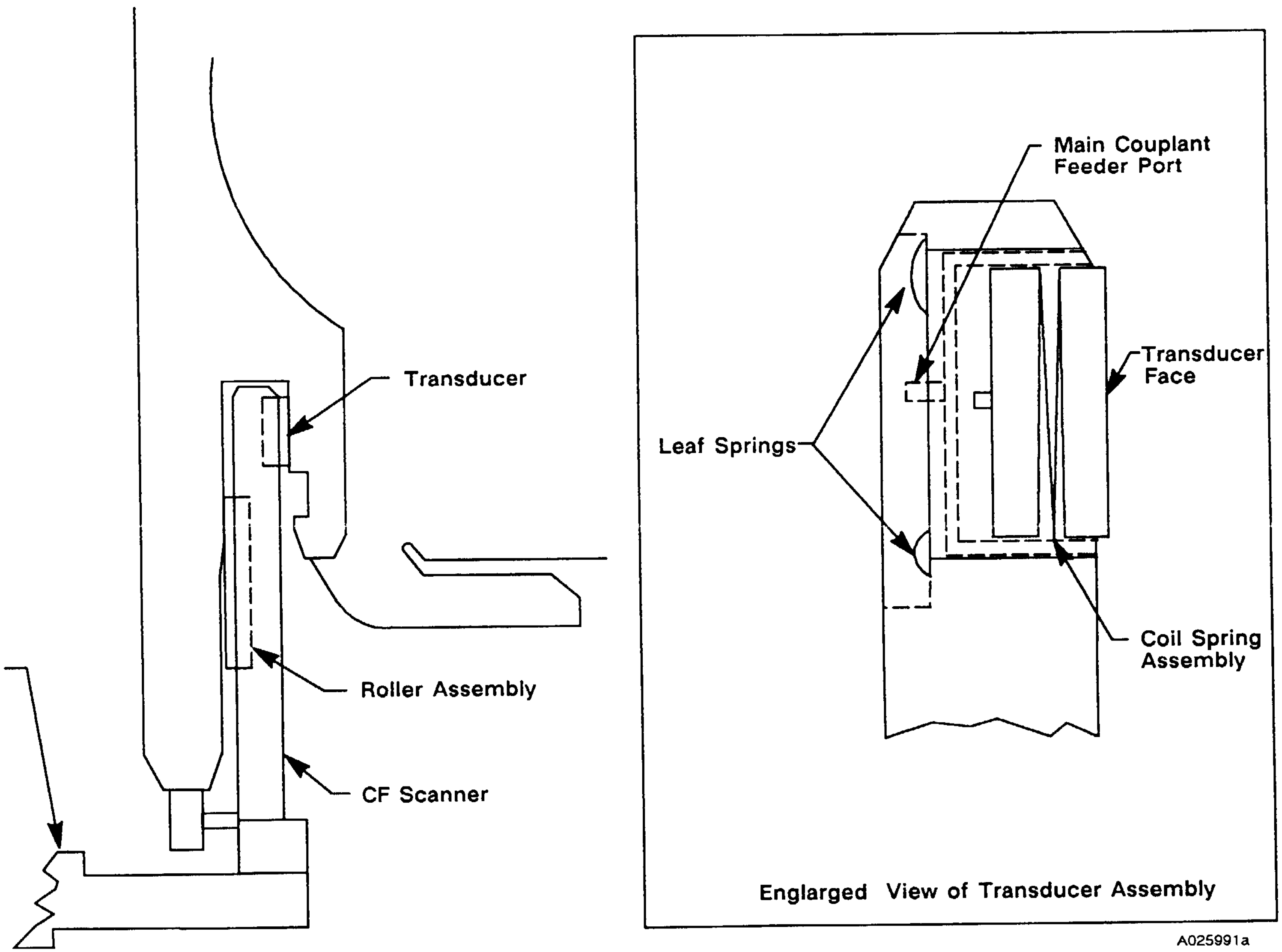
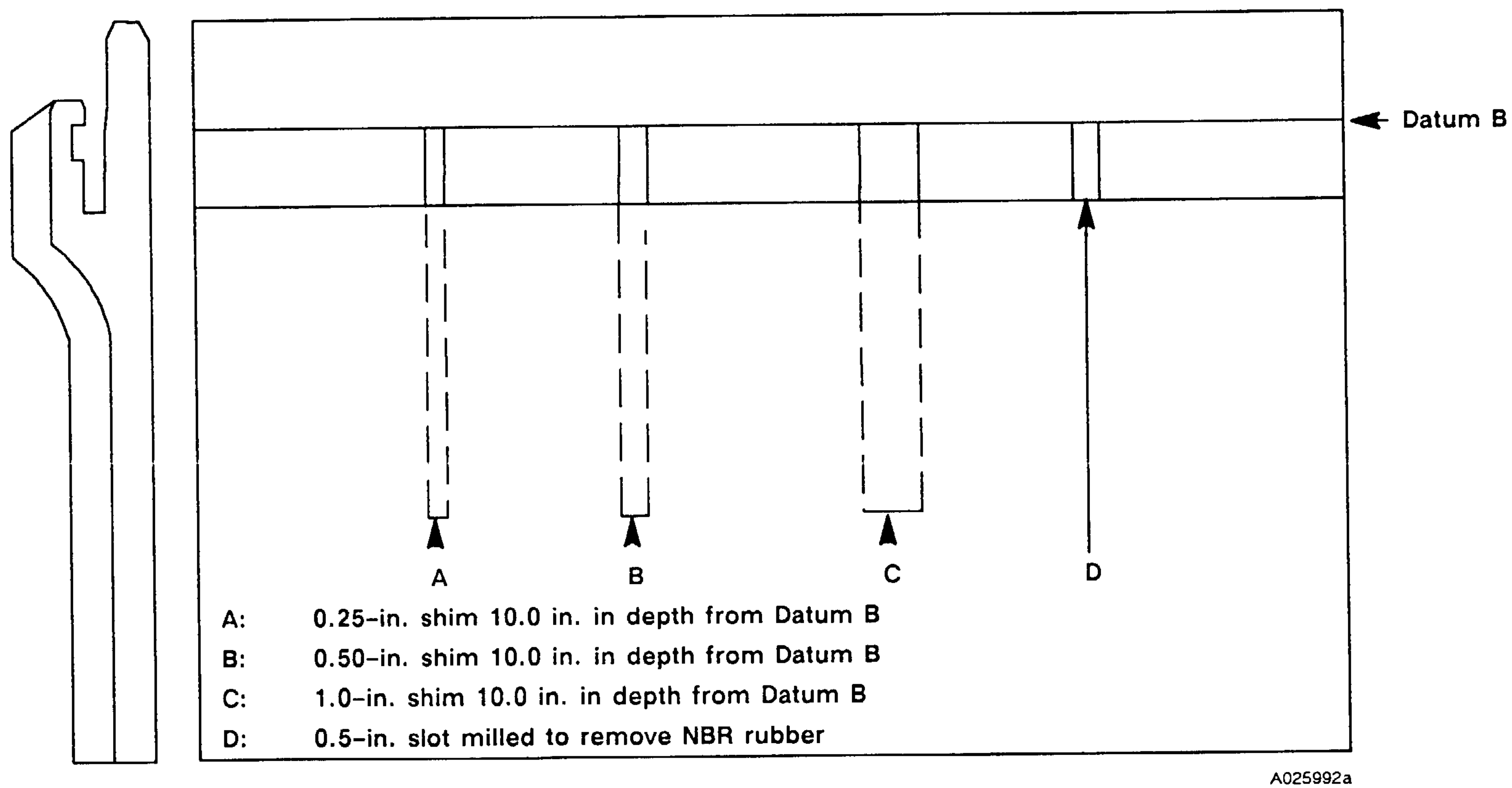


Figure 2. CF Scanner and Field Joint Interface



Note: All shims were placed between rubber and Chemlok® prior to layup

Not to scale

Figure 3. Unbond Diagram for CF Ultrasonic Calibration Standard (2U129702)

2

OBJECTIVES

The objectives of CTP-0085 were intended to qualify the tooling and techniques used in the RSRM CF case-to-insulation bondline inspection. The objectives were:

a. Verify that the ultrasonic inspection kit has the capability of detecting 1.0 by 1.0-in. unbonded surfaces, which are not detectable by visual inspection (CDW2-3452, Para. 3.2.1.1).

b. Verify that the ultrasonic inspection kit interfaces with the field joint of the segment and requires no special tools for attachment and release (CDW2-3452, Para. 3.2.1.2).

c. Verify that the ultrasonic inspection kit can be transported (CDW2-3452, Para. 3.2.8).

3

EXECUTIVE SUMMARY

3.1 SUMMARY

This section contains an executive summary of the key results from test data evaluation. Additional information and details can be found in Section 6.

The CF scanner was calibrated on the CF ultrasonic calibration standard, which had an intentional 1.0 by 1.0-in. case-to-insulation unbond. The CF scanner was then used to scan a 60-deg area of the CF field joint. Calibration of the CF scanner was then rechecked on the calibration standard to ensure that the calibration settings did not change during the case scan. This procedure was successfully performed five times to qualify the unbond detection capability of the CF scanner. No unbonds were detected on the case joint. The CF scanner successfully interfaced with the CF field joint throughout the scanning procedure. During the test, the CF scanner and the CF field joint were not degraded.

3.2 CONCLUSIONS

The following columns list the conclusions as they relate specifically to the objectives. Additional information to support each conclusion can be found in Section 6.

Objective	CDW2-3452 Paragraph	Conclusion
a. Verify that the ultrasonic inspection kit has the capability of detecting 1.0 by 1.0-in. unbonded surfaces, which are not detectable by visual inspection.	Paragraph 3.2.1.1., General Performance. This inspection tool provides a means of detecting subsurface bondline failures which are not detectable by visual inspection. (Compressed "kissing" unbonds are not detectable.) The ultrasonic tool shall have the capability of detecting unbonds of 1.0 by 1.0 in. Use of this tool shall permit unbonds to be detected and repaired before stacking. Use of the inspection kit shall not affect the reusability requirements for the case segment and associated equipment denoted in CPW1-3600, Table IV.	*Verified.* The CF scanner was calibrated over an intentional 1.0 by 1.0-in. unbond, then used to scan a 60-deg area of a case joint, and then checked for calibration accuracy. This procedure was successfully performed five times. This test qualified the unbond detection capability of the CF scanner/URBIS.

	Objective	CDW2-3452 Paragraph	*Conclusion*
b.	Verify that the ultrasonic inspection kit interfaces with the field joint of the segment and requires no special tools for attachment and release.	Paragraph 3.2.1.2, Installation Function. The ultrasonic case-to- insulation bondline inspection kit shall interface with the field joint of the segment. Attachment and release of the fixture shall be efficient and require no special tools.	*Verified.* The CF scanner successfully interfaced with the CF field joint throughout the scanning procedure without the aid of additional tools. During the test, the CF scanner and the CF field joint were not degraded.
c.	Verify that the ultrasonic inspection kit can be transported.	Paragraph 3.2.8, Transportability/Transpor-tation. The Case-to-Insulation Bondline Inspection Kit, Ultrasonic, shall be capable of being handled and transported manually. The kit shall also be capable of being handled and transported by any suitable means during transportation to the launch site. The RSRM Segment Case-to-Insulation Bondline Inspection Kit, Ultrasonic, shall be packaged in accordance with NHB 6000.1 to protect it from the shipping environment.	*Verified.* The complete URBIS is designed to be broken down into components that are placed in protective cases for transportability. This testing verified the transportability of the CF scanner/URBIS.

3.3 RECOMMENDATIONS

Due to the successful completion of testing under CTP-0085, the CF scanner/URBIS should be considered qualified for RSRM inspections at Thiokol Corporation's Wasatch Space Operations and at KSC.

The following additional recommendation has been made:

An improved CF scanner should be implemented at the earliest possible convenience. The current configuration of the CF scanner, qualified under CTP-0085, contains many points of mechanical instability that can effect the overall ultrasonic signal response. The major mechanical features of the current CF scanner that cause instability to the inspection are:

a. The magnetic drive track. The magnetic tracks typically contain high and low spots which cause exaggerated motion to occur at the end of the scanner arm.

b. The CF scanner configuration. This configuration contains several unstable connection points. The scanner-to-arm configuration is a cantilever beam, and the transducer-to-scanner arm configuration is also a cantilever beam (Figure 1). This configuration allows points of rotation where, for example, the motion created by low spots in the magnetic drive track are amplified.

A new generation CF scanner, designated the sigma scanner, will further enhance the capability of this fundamentally strong technique. The sigma scanner has all the capabilities of the current CF scanner and will interface with the URBIS. The sigma scanner is also self propelled, does not need a magnetic track, eliminates the unstable connection points of the current scanner, and can be used to inspect the bondline behind the CF O-ring groove.

4

INSTRUMENTATION

Test instruments were electrically zeroed and calibrated in accordance with MIL-STD-45662.

5

PHOTOGRAPHY

Still black and white photographs of the test setup were taken. Copies of the photographs taken (series No. 115650) are available from the Thiokol Corporation Photographic Services Department.

6

RESULTS AND DISCUSSION

6.1 TEST ARTICLE COMPONENT DESCRIPTION

The following inspection components were used during the CTP-0085 qualification:

Component	Part No.	Serial No.
URBIS	2U129431-01	S-A51866
AMAPS 2090 Scanner		S-A51865-8
Ultrasonic Transducer	9402	89004

Prior to testing, the URBIS used in conjunction with the CF inspection was qualified under CTP-0100. The URBIS qualification consisted of routine maintenance, calibration, and an evaluation of the performance of the system.

6.2 INSPECTION SCAN PARAMETERS

The scan parameters used during the calibration sequences and during the joint scan are described below. (Additional information on unbond detection is discussed in CTP-0100.)

C-scan: This inspection scan presents a planar view of the bondline, giving both unbond size and location within this view. This scan is performed first, primarily to show the location of unbonds.

B-scan: The B-scan inspection presents a cross-sectional view of the test article with respect to the depth of the unbond. This inspection scan is used to measure the intensity of a signal response, enabling the operator to clearly distinguish between bonded and unbonded surfaces. The B-scan is also used to size unbonds.

Radio frequency (RF) waveform: This waveform presents the transducer response signal, in which larger amplitudes indicate unbonds.

6.3 TEST DESCRIPTION, RESULTS, AND DISCUSSION

Qualification of the CF tool and inspection technique consisted of the following three steps:

1. The CF scanner and the inspection technique were calibrated on the CF ultrasonic calibration standard (2U129702), which contained an intentional 1.0 by 1.0-in. case-to-insulation unbond. This calibration, known as "calibration in," enabled operators to clearly distinguish the 1.0 by 1.0-in. unbond from the bonded regions.

2. The CF scanner was then used to scan a 60-deg area of the RSRM-13A aft center segment CF field joint (P/N 1U76667-01, S/N 0000030). The center of the 60-deg arc was at the top dead center of the case joint to allow gravity-induced loads to assist in revealing potential unbonds.

3. Calibration of the CF scanner and technique (on the calibration standard) was repeated upon completion of the case joint scanning. This calibration, known as "calibration out", ensured that the initial calibration settings did not change during the case scan.

The three stages of the CF scan sequence were successfully performed five times over the same 60 deg of the CF joint to qualify the unbond detection capability of the CF scanner. No unbonds were detected on the case CF joint.

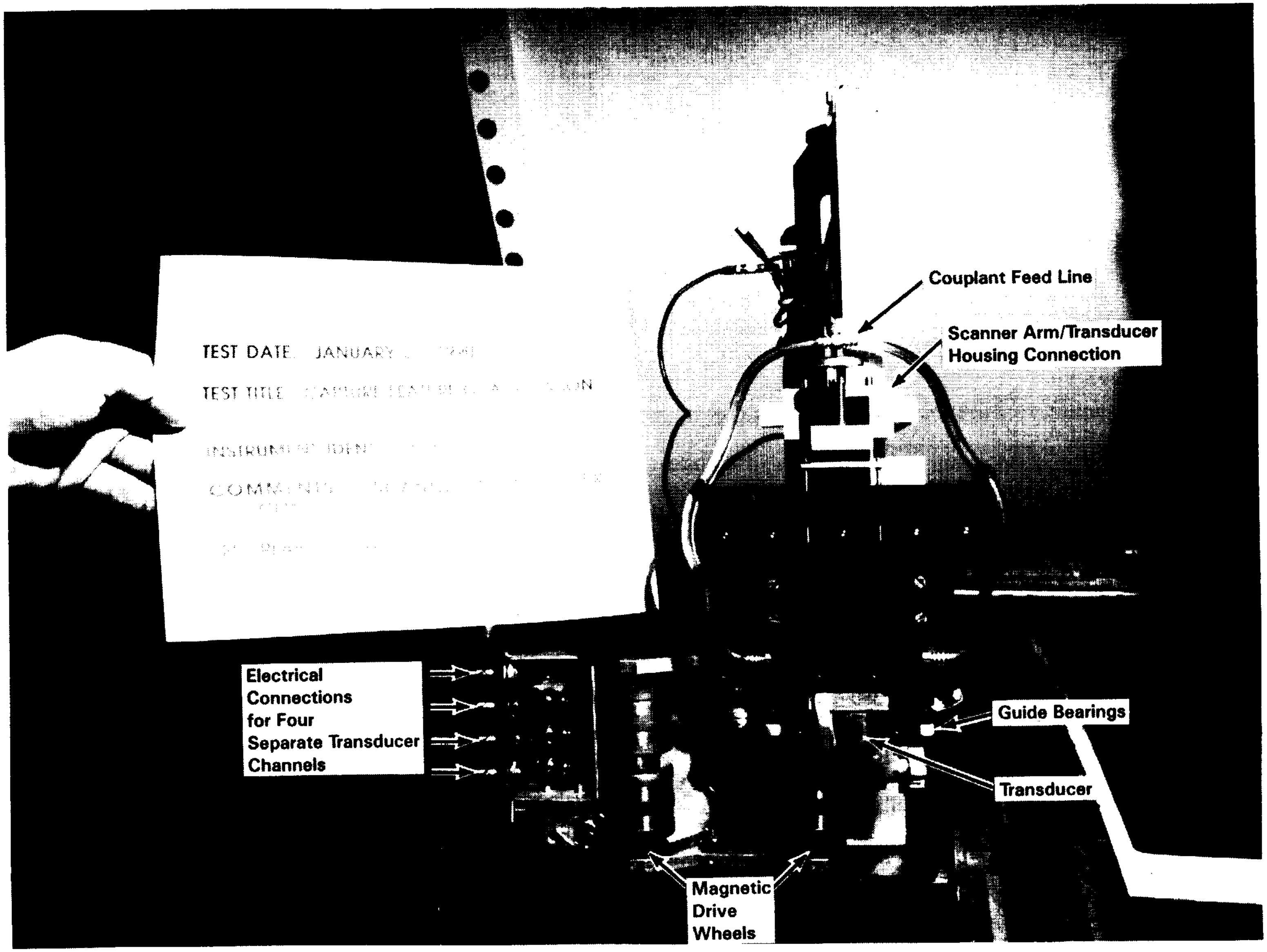
Photographic coverage of the qualification test is shown in Figures 4 through 13. (Photographs of the calibration-out sequence were not taken because this sequence is the same as the calibration-in sequence).

The inspection results are presented in Figures 14 through 28. Each scan sequence run includes the C-scan, the B-scan, the RF waveform for the calibration in, the segment scan, and the calibration out. Figure 14 shows the C- and B-scan presentations (unbonded regions shown in red) and the RF waveform unbond signal response for the run No. 1 calibration-in sequence. Figure 15 shows the same information for the 60-deg case scan (no unbonds were detected). Figure 16 shows the C- and B-scan presentations and the RF waveform unbond signal response for the run No. 1 calibration-out sequence. Figures 17 through 28 repeat the same information for qualification runs 2 through 5.

The CF scanner successfully interfaced with the CF field joint throughout the scanning procedure. Figure 13 shows the scanner-to-CF field joint interface. During the test, the CF scanner and the CF field joint were not degraded.

The complete URBIS is designed to be broken down into components that are placed in protective cases for transportability. This testing verified the transportability of the CF scanner/URBIS.

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

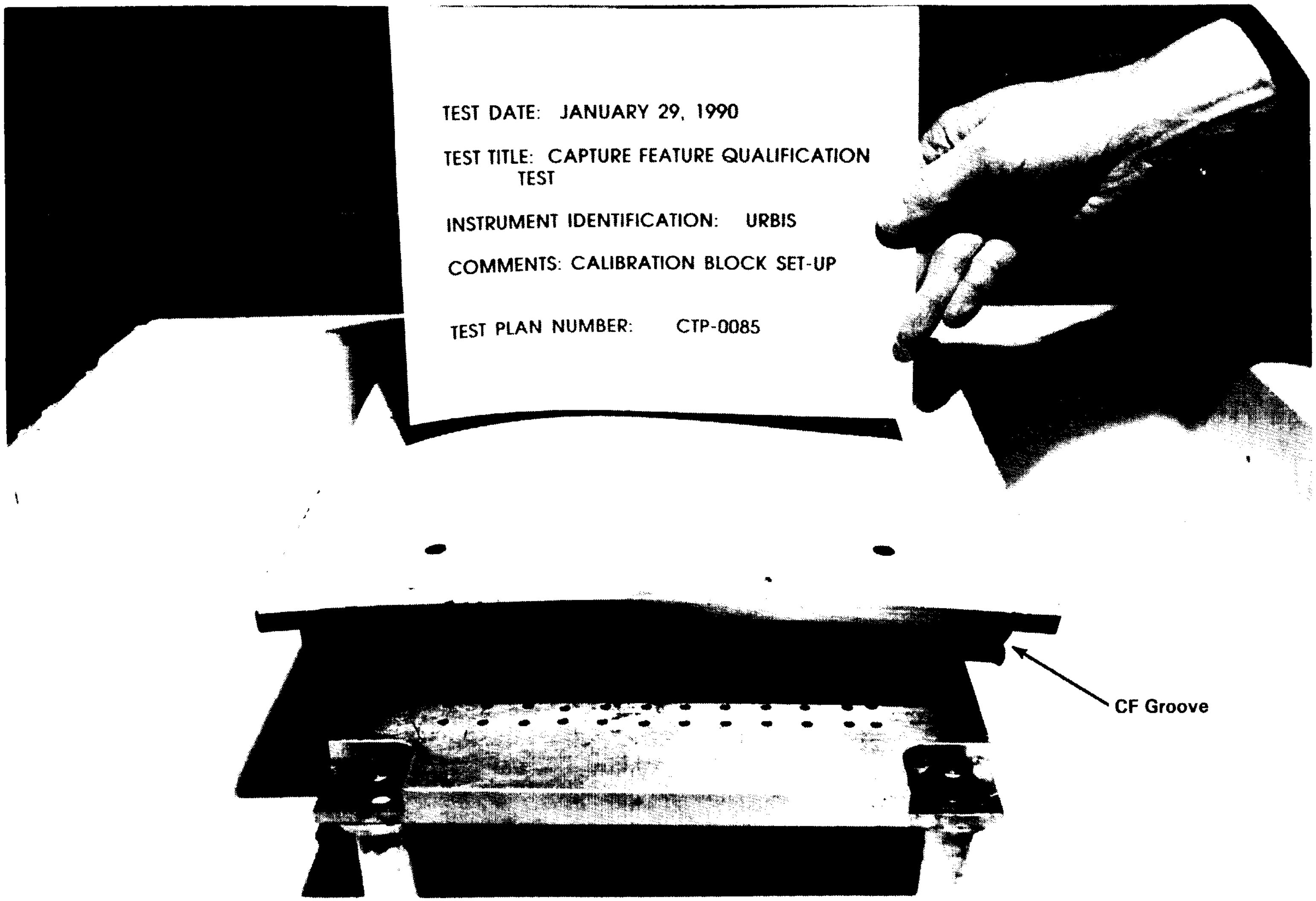


N11565O-1

90456-2.1

Figure 4. CF Scanner and Transducer Configuration

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

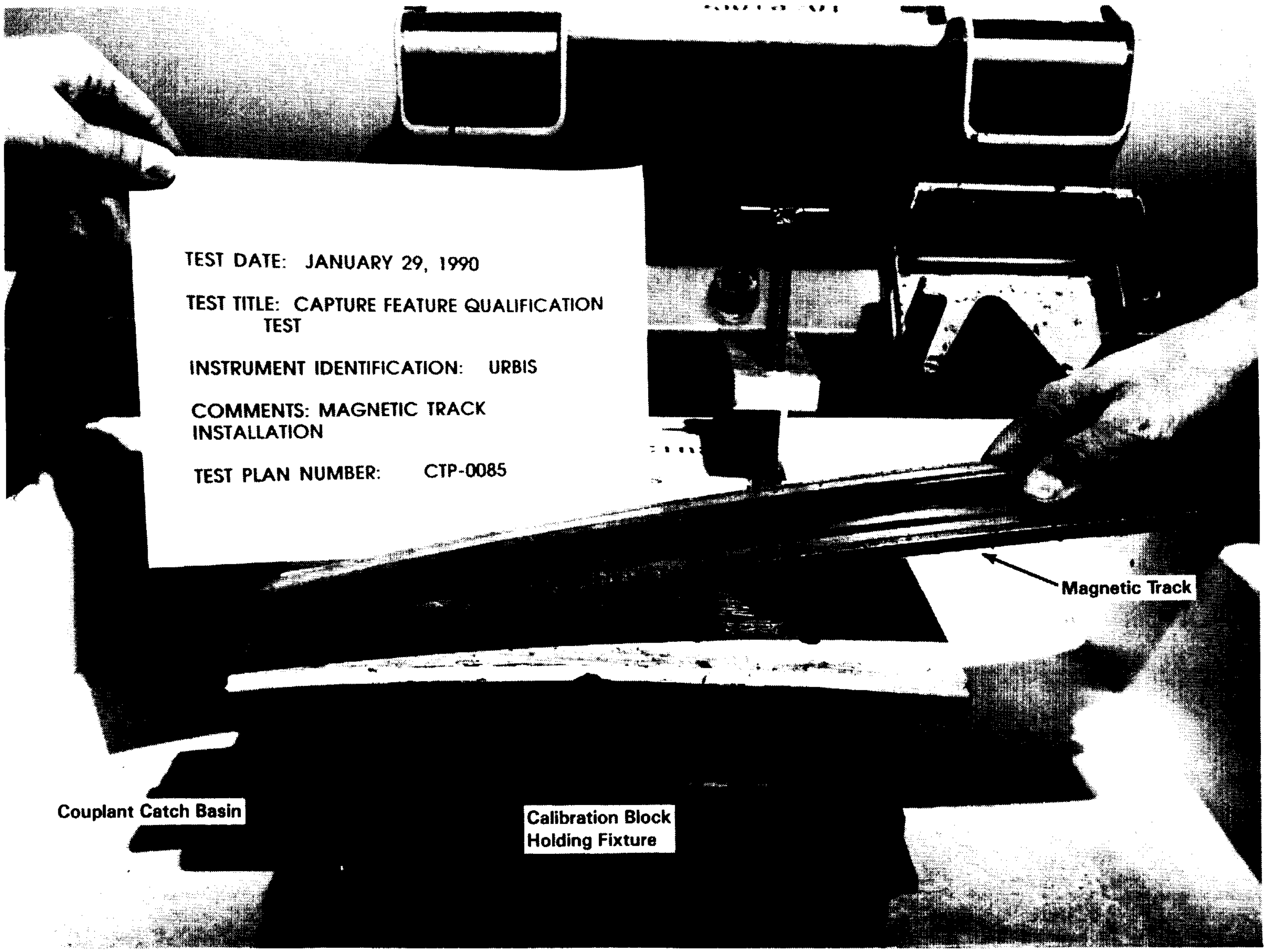


N115650-2

90456-2.2

Figure 5. CF Ultrasonic Calibration Standard Setup

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

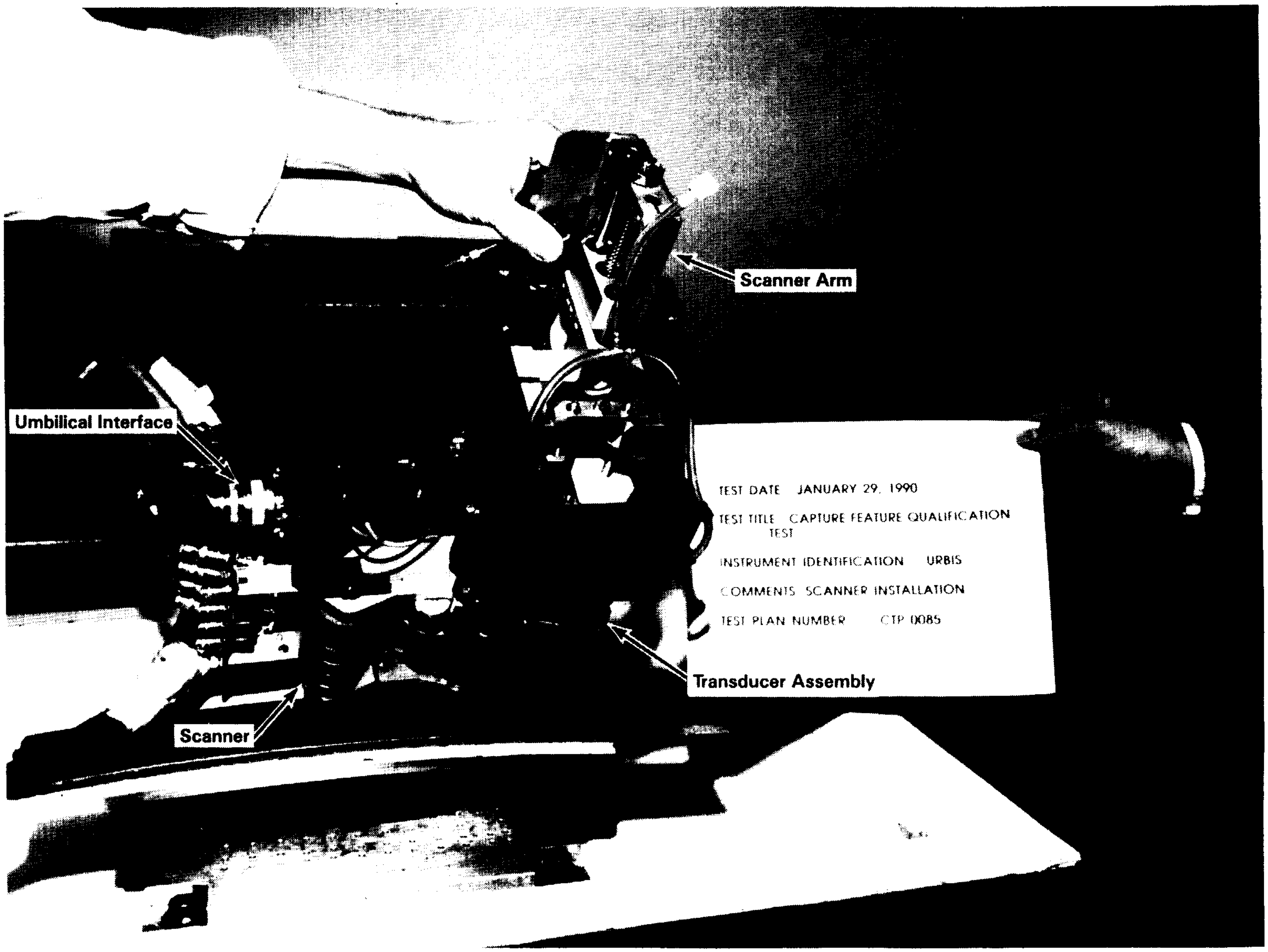


N115650-3

90456-2.3

Figure 6. Magnetic Track Installation on Calibration Standard

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

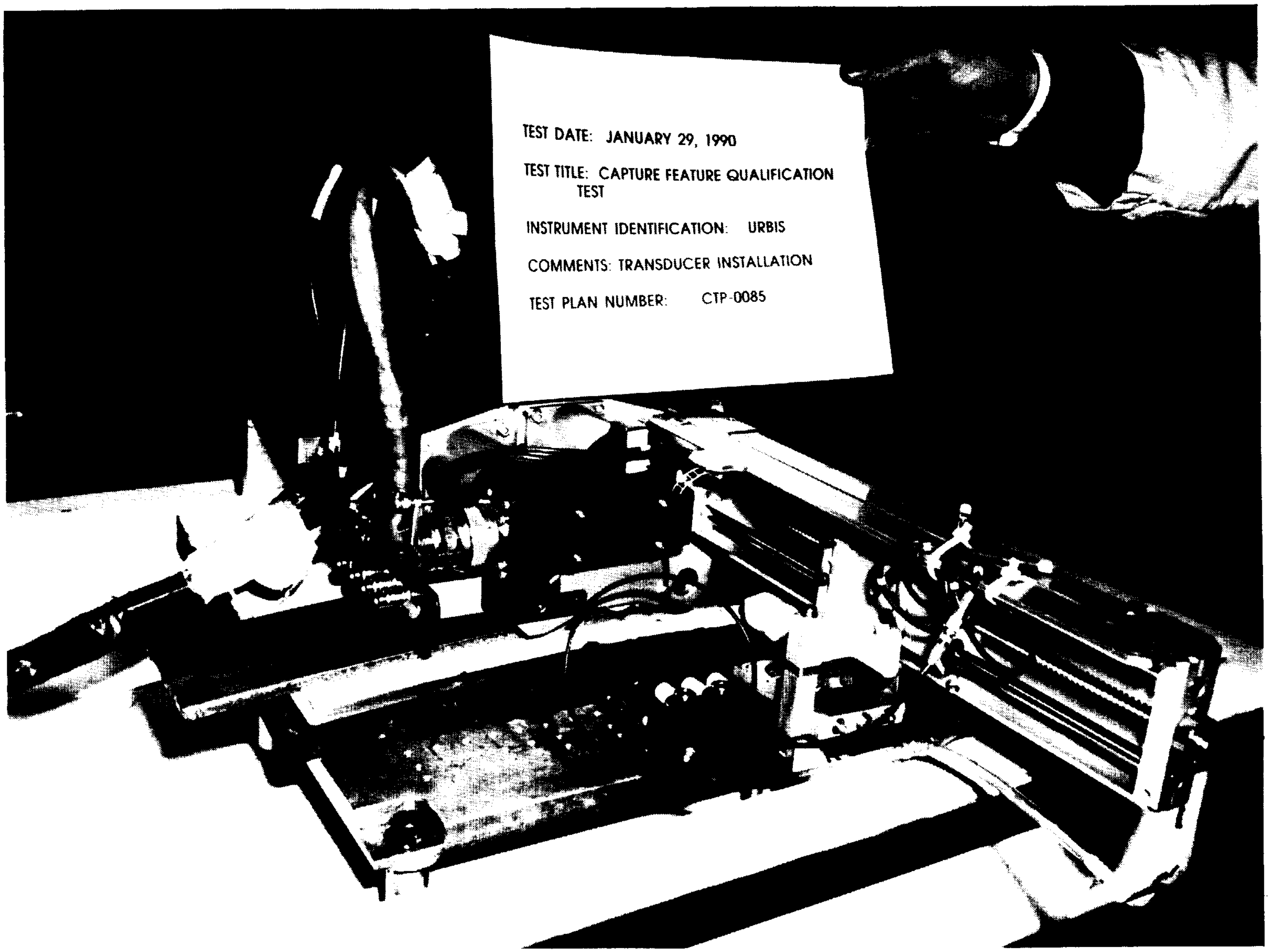


N115650-4

90456-2.4

Figure 7. CF Scanner Installation on Calibration Standard

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH



N115850-5

90456-2.5

Figure 8. Transducer Installation on Calibration Standard

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

N115650-6

90456-2.6

Figure 9. Calibration Run

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

N115650-7

Figure 10. End Stand Positioned Next to Segment

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

N115650-8

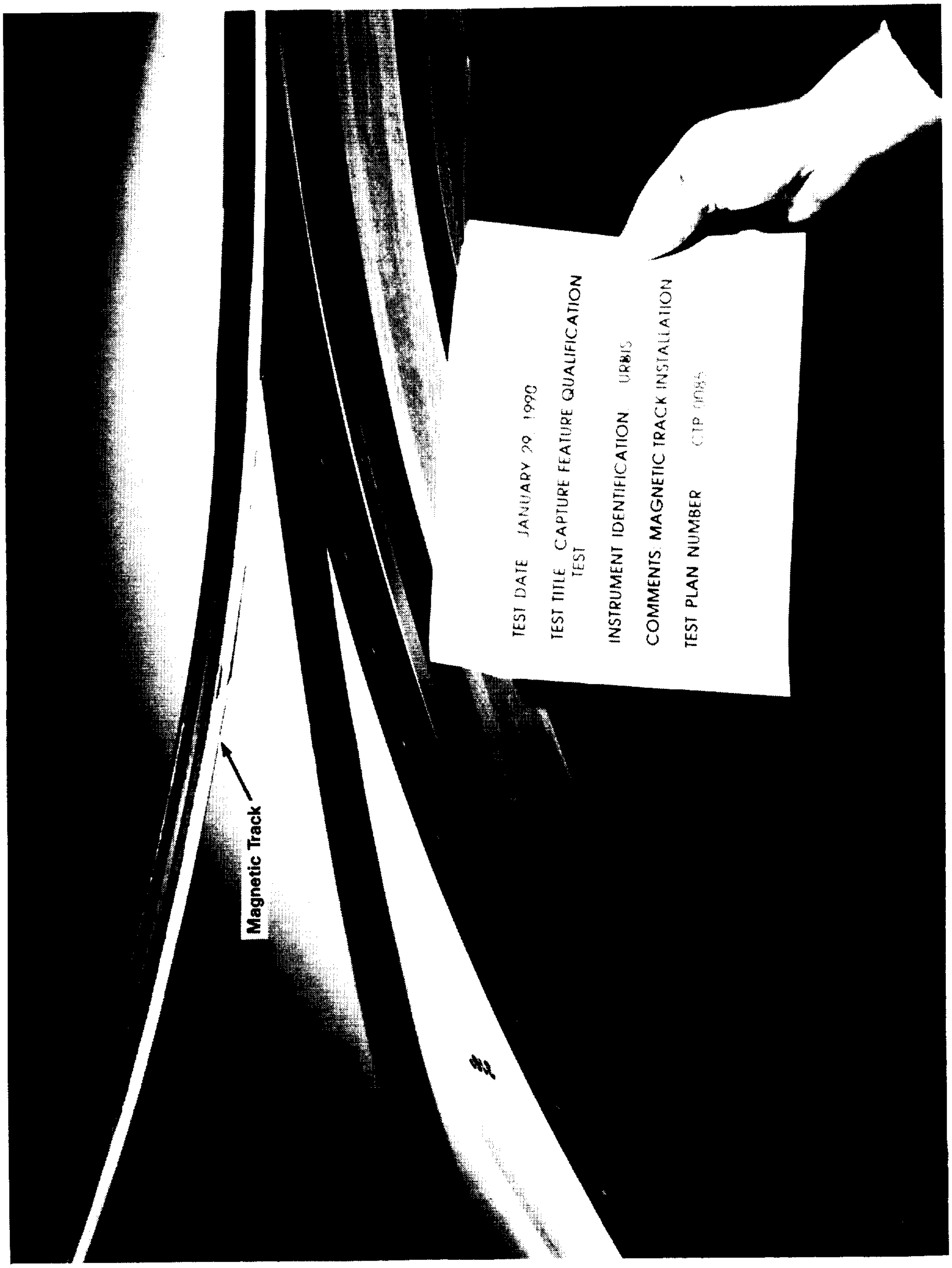


Figure 11. Magnetic Track Installation on Segment

90456-2.8

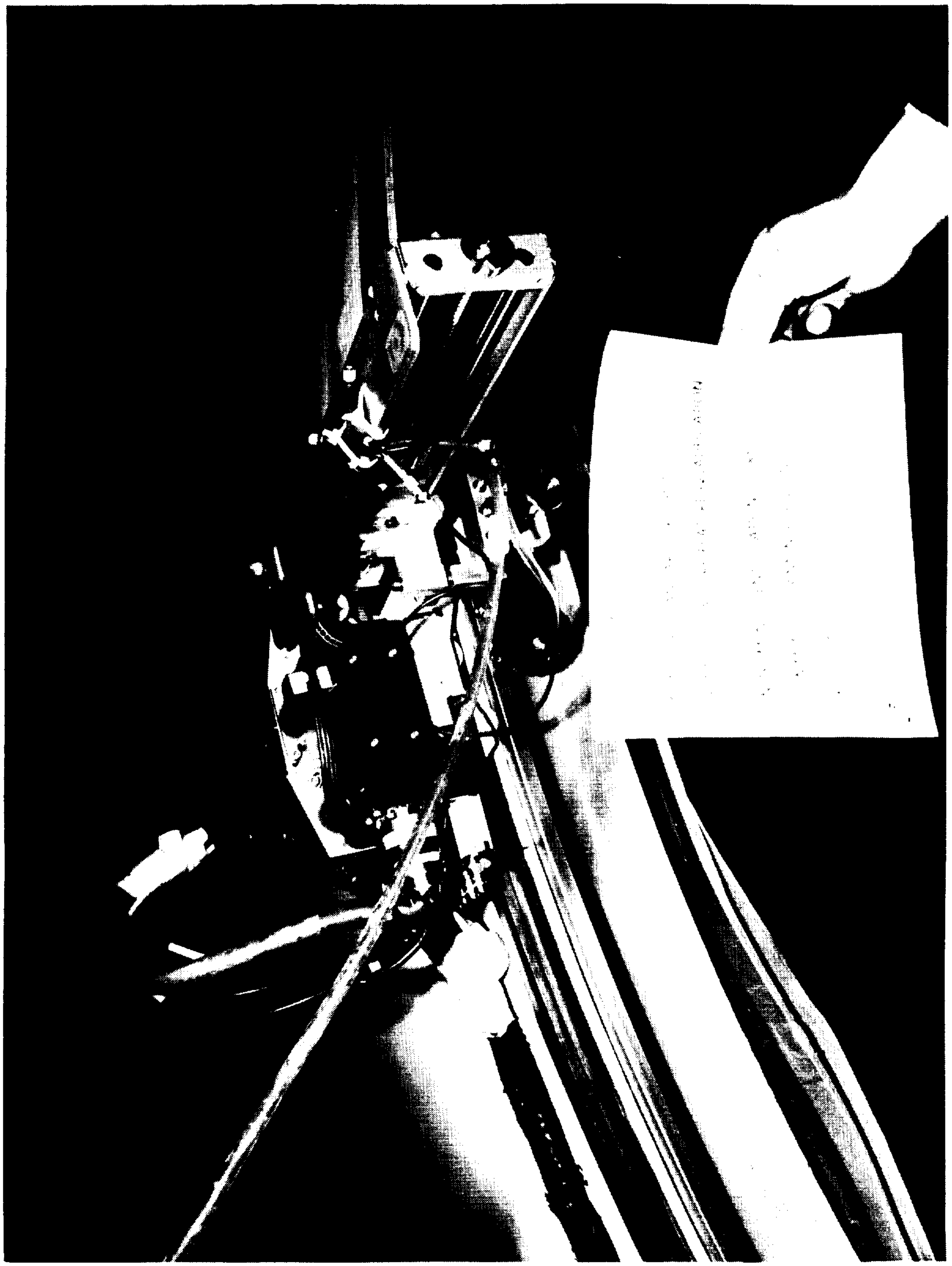
ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

N115650-9

90456-2.9

Figure 12. CF Scanner Installation on Magnetic Track

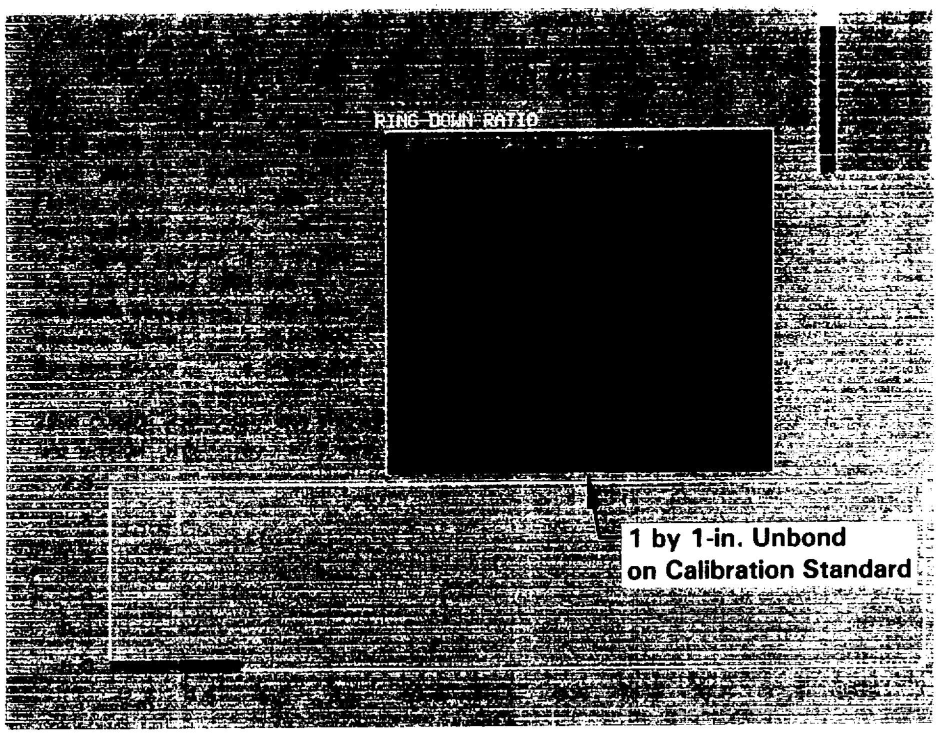
N115650-10



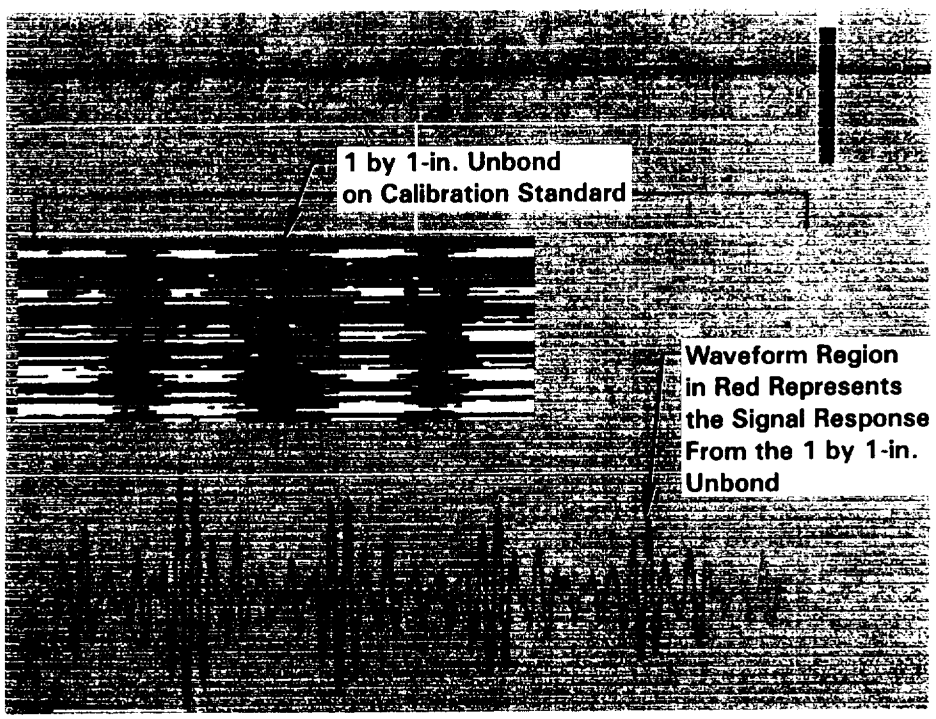
90456-2.10

Figure 13. Scanning Sequence on Segment

ORIGINAL PAGE IS
OF POOR QUALITY

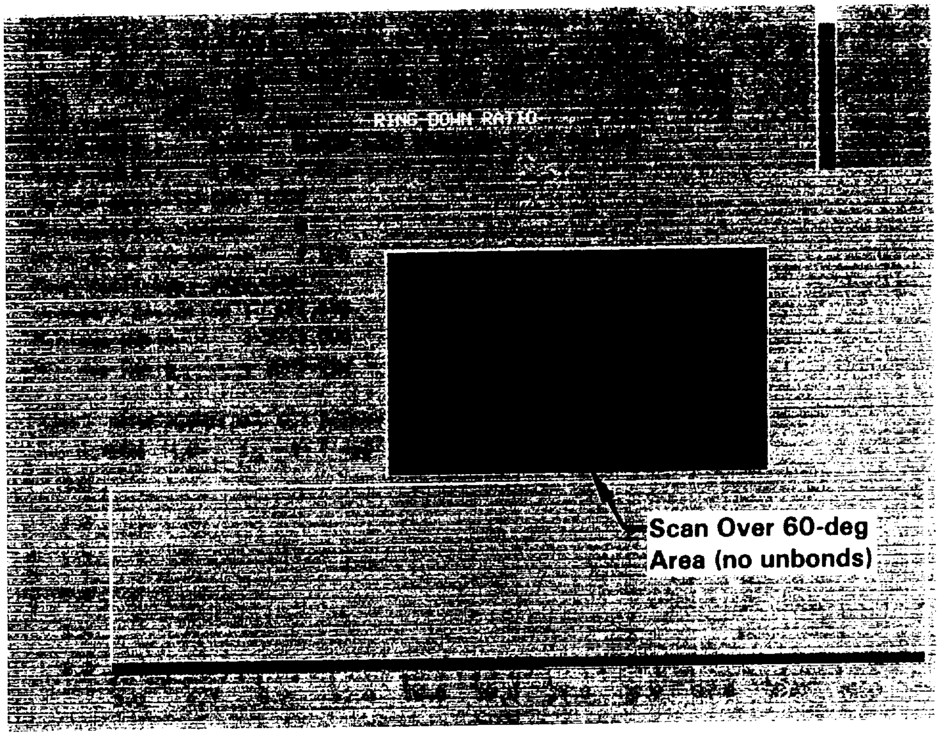


C-scan Presentation

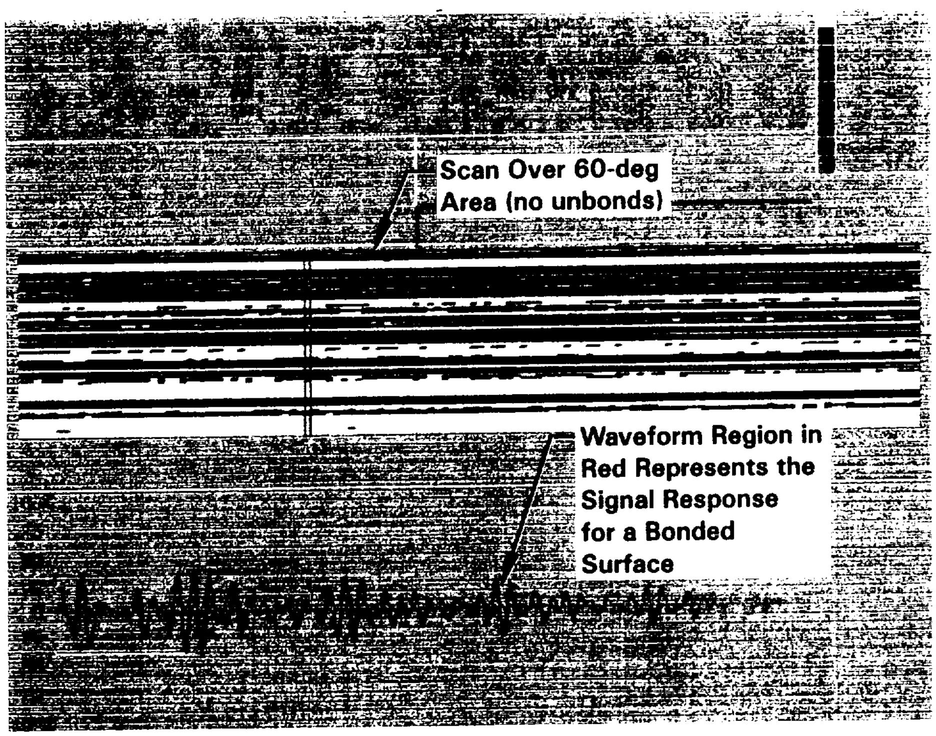


B-scan Presentation

Figure 14. Calibration-in Sequence--Scan Run No. 1



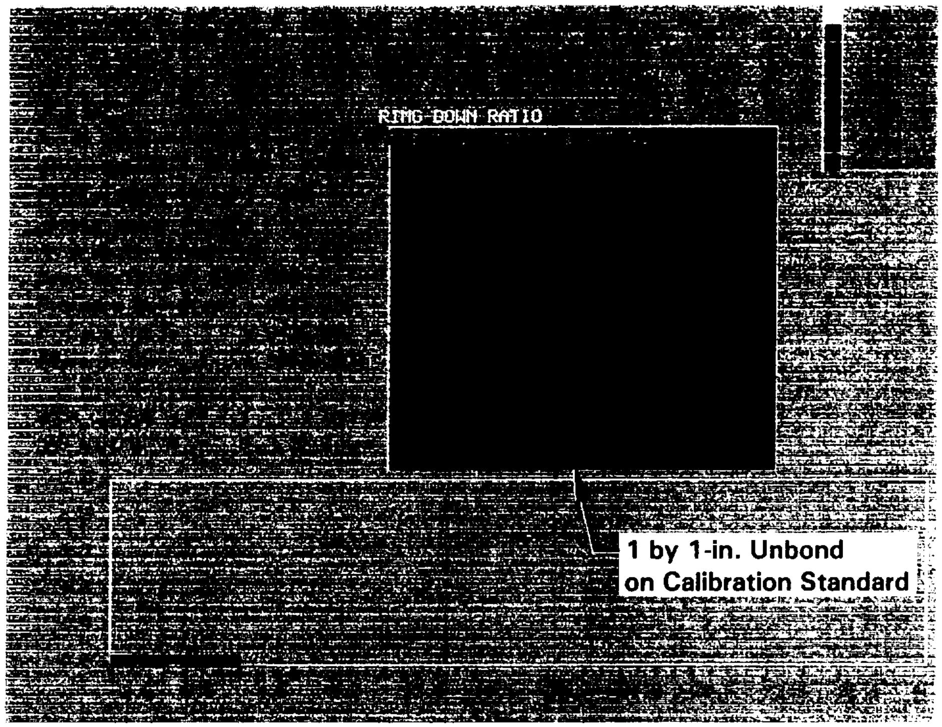
C-scan Presentation



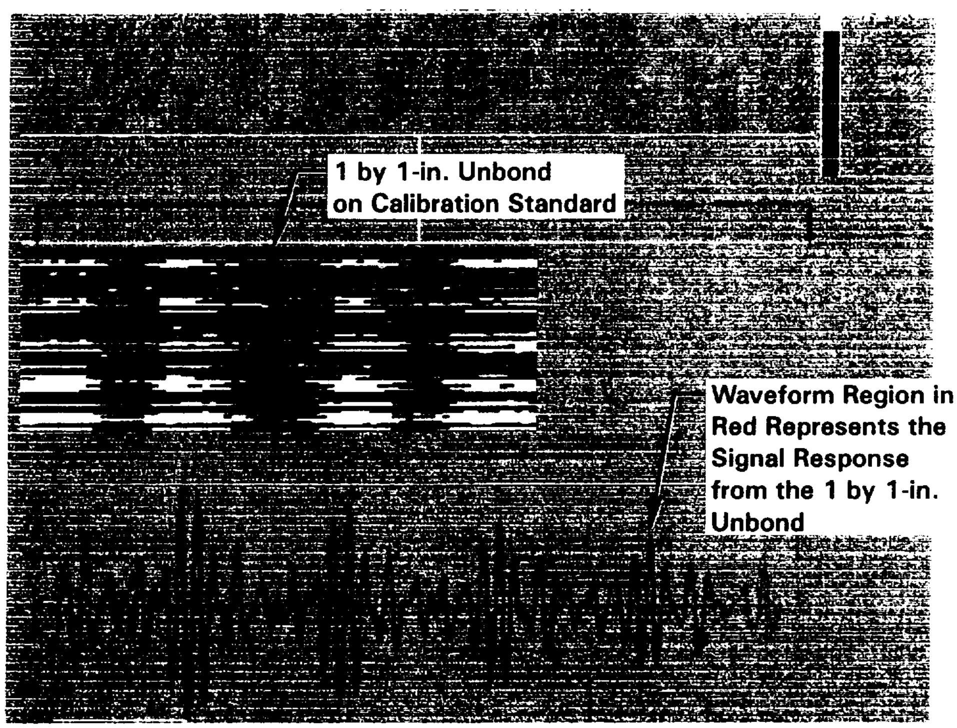
B-scan Presentation

Figure 15. Scanning Sequence--Scan Run No. 1

ORIGINAL PAGE IS
OF POOR QUALITY

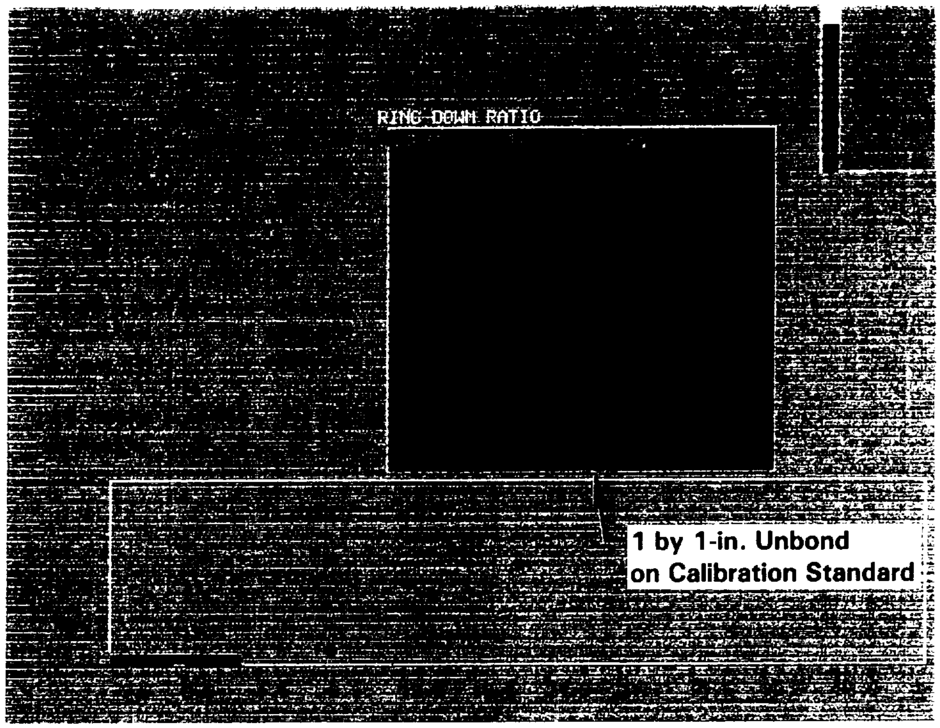


C-scan Presentation

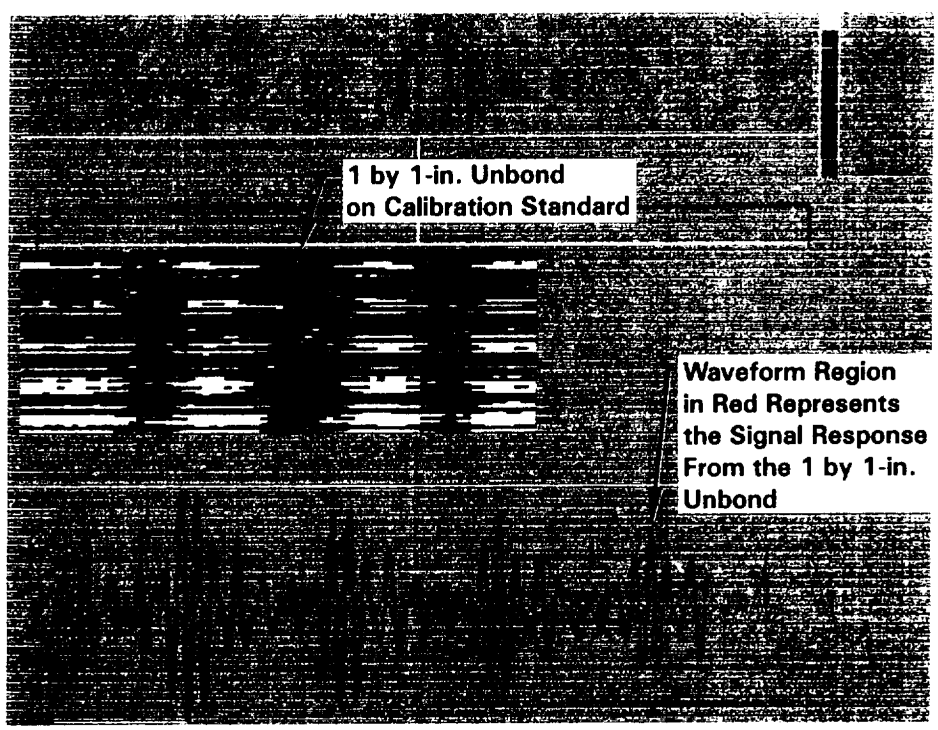


B-scan Presentation

Figure 16. Calibration-out Sequence--Scan Run No. 1



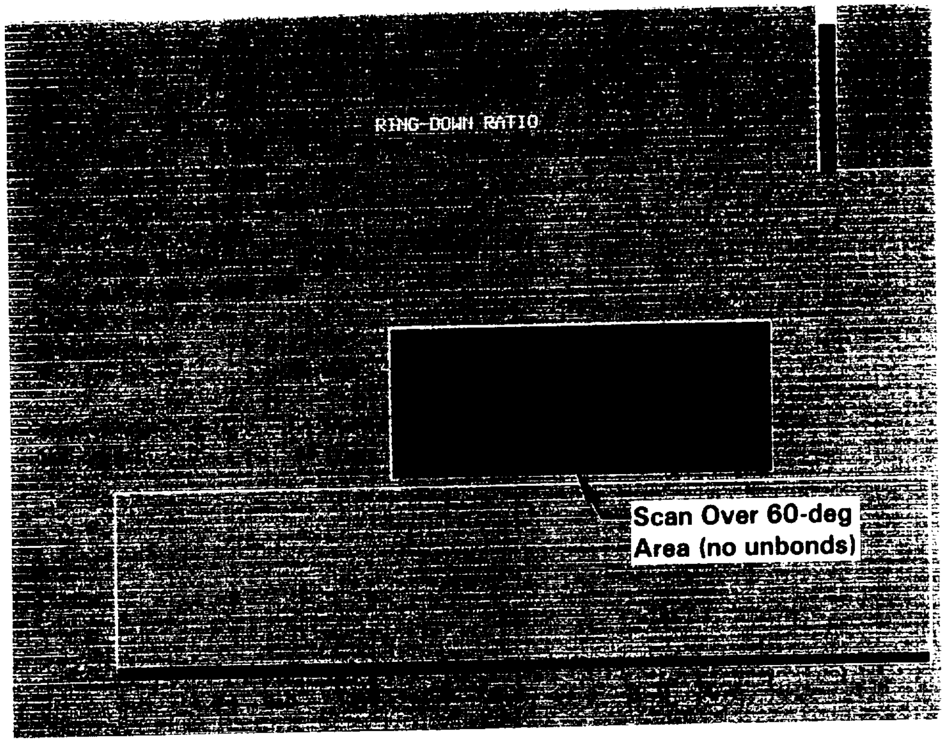
C-scan Presentation



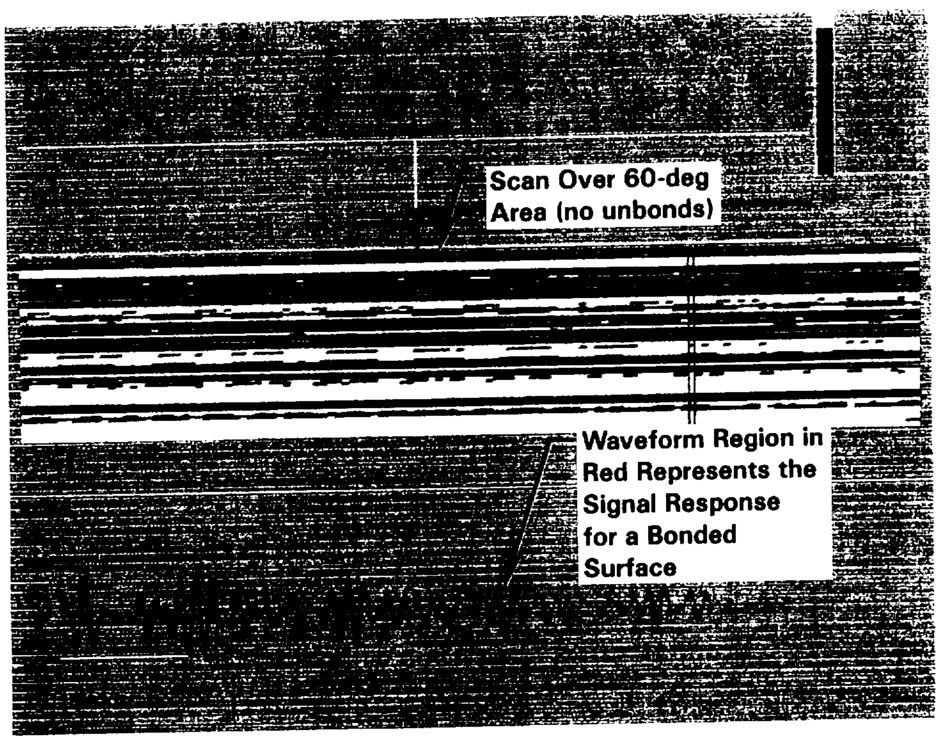
B-scan Presentation

Figure 17. Calibration-in Sequence--Scan Run No. 2

ORIGINAL PAGE IS
OF POOR QUALITY

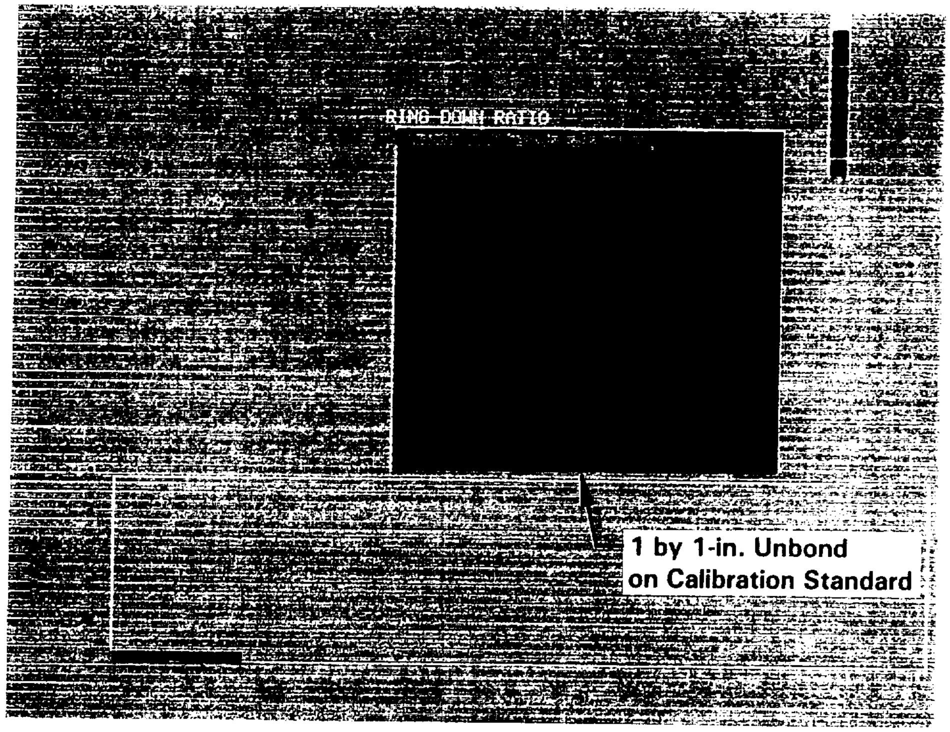


C-scan Presentation

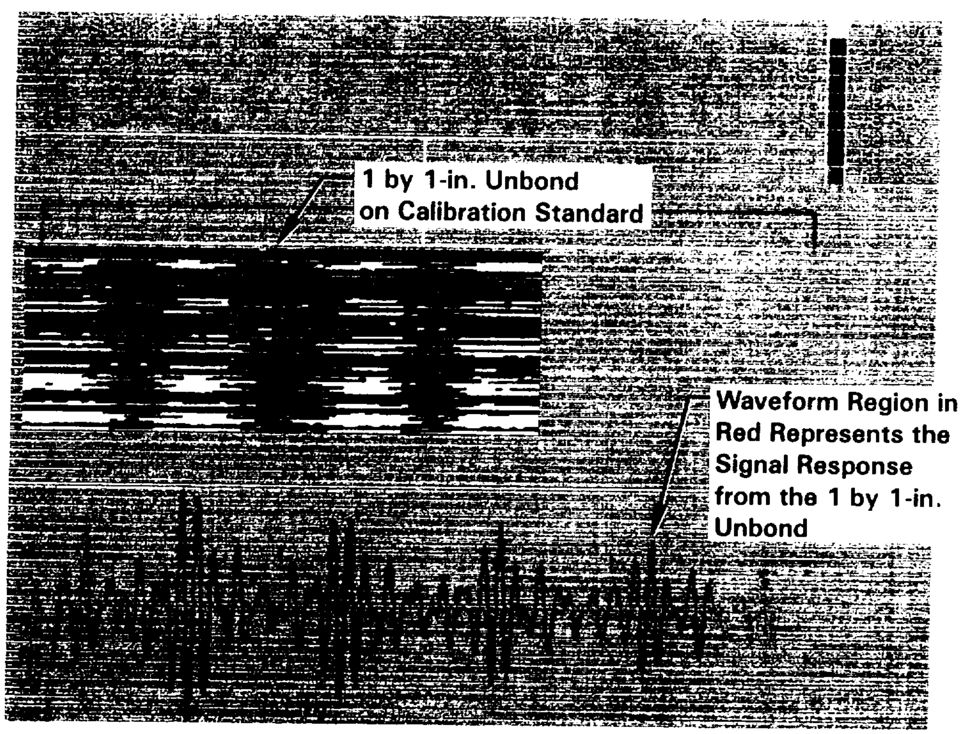


B-scan Presentation

Figure 18. Scanning Sequence--Scan Run No. 2



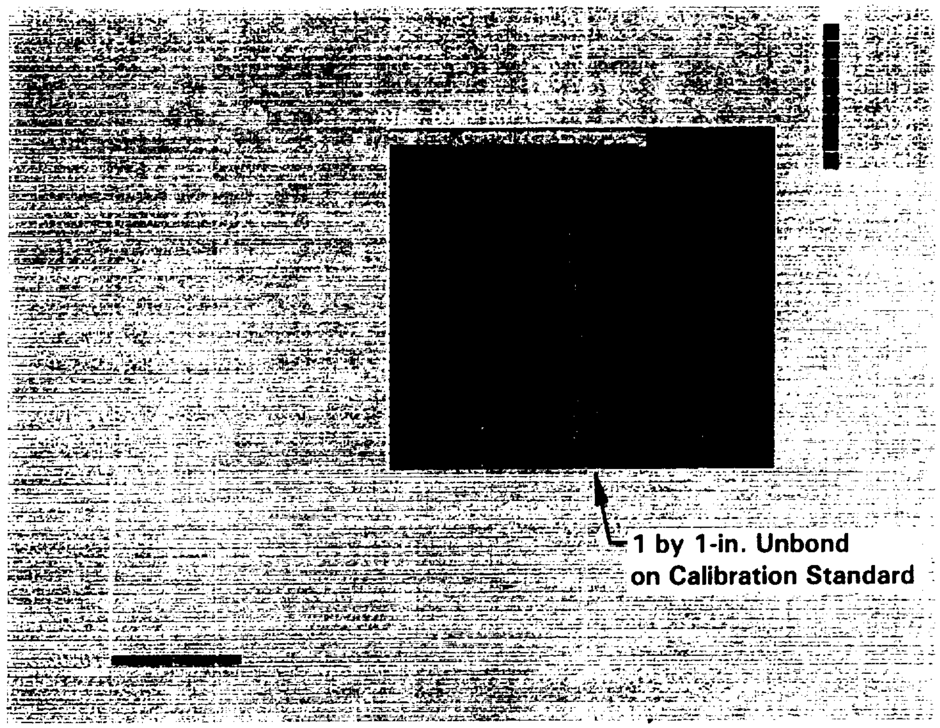
C-scan Presentation



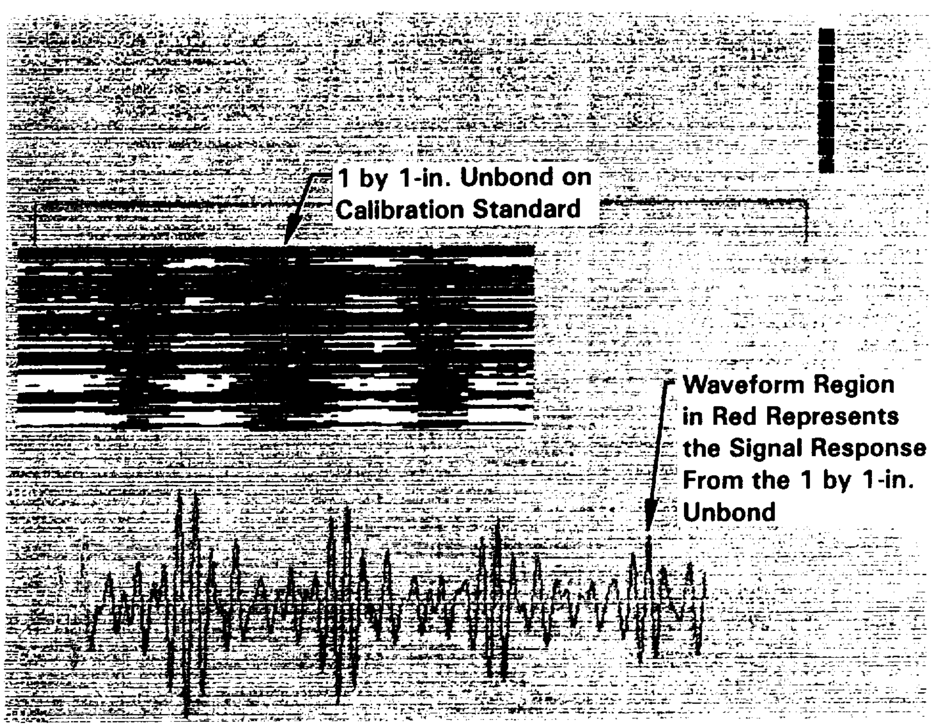
B-scan Presentation

Figure 19. Calibration-out Sequence--Scan Run No. 2

ORIGINAL PAGE IS
OF POOR QUALITY

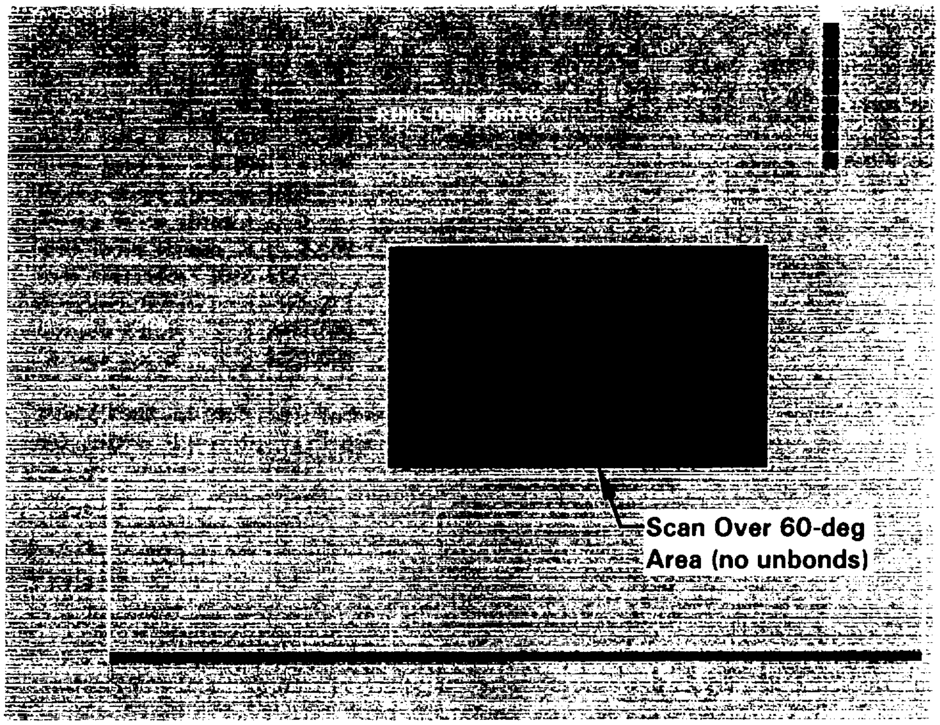


C-scan Presentation

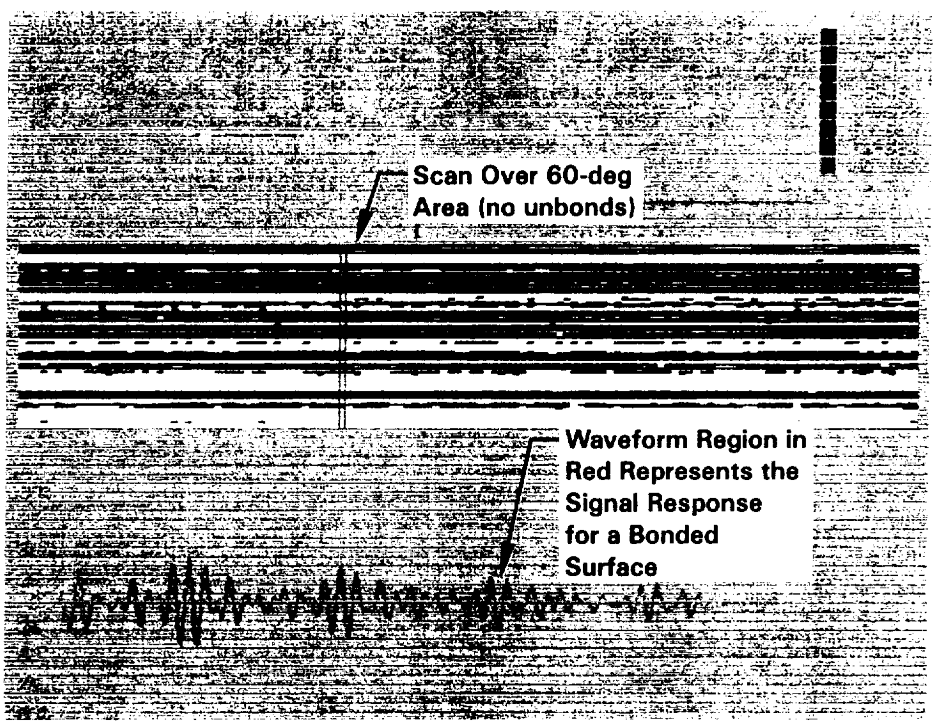


B-scan Presentation

Figure 20. Calibration-in Sequence--Scan Run No. 3

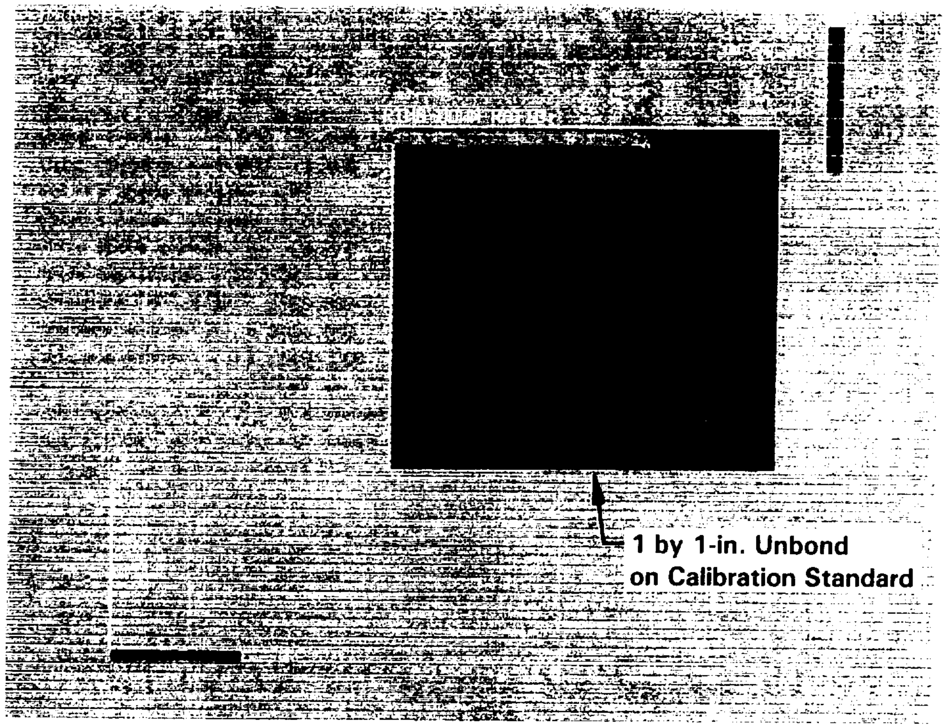


C-scan Presentation

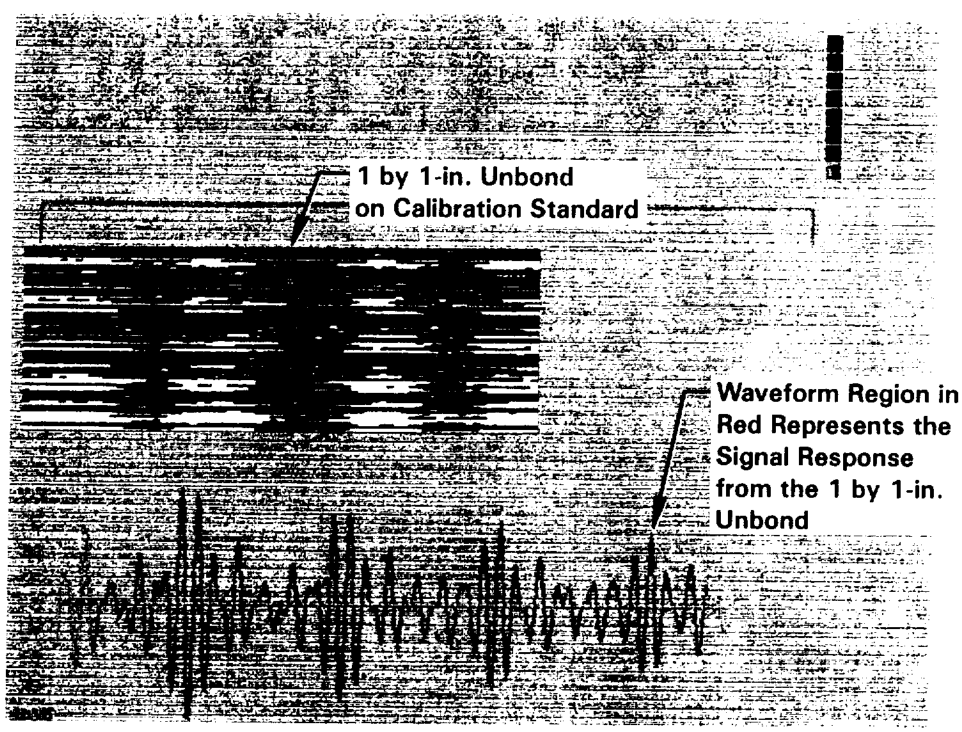


B-scan Presentation

Figure 21. Scanning Sequence--Scan Run No. 3

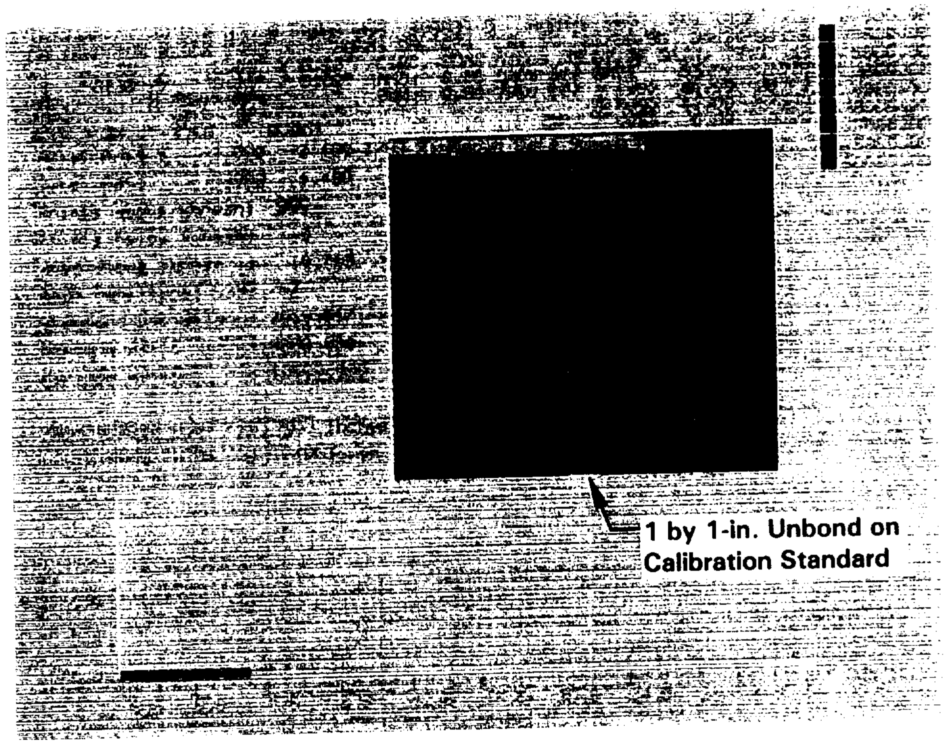


C-scan Presentation

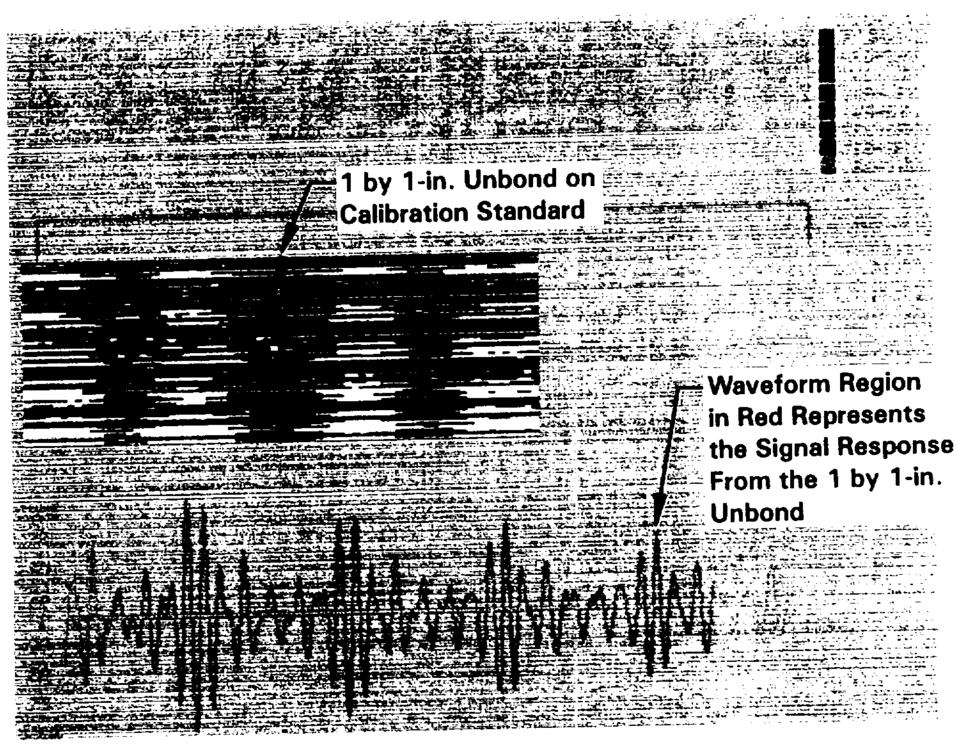


B-scan Presentation

Figure 22. Calibration-out Sequence--Scan Run No. 3



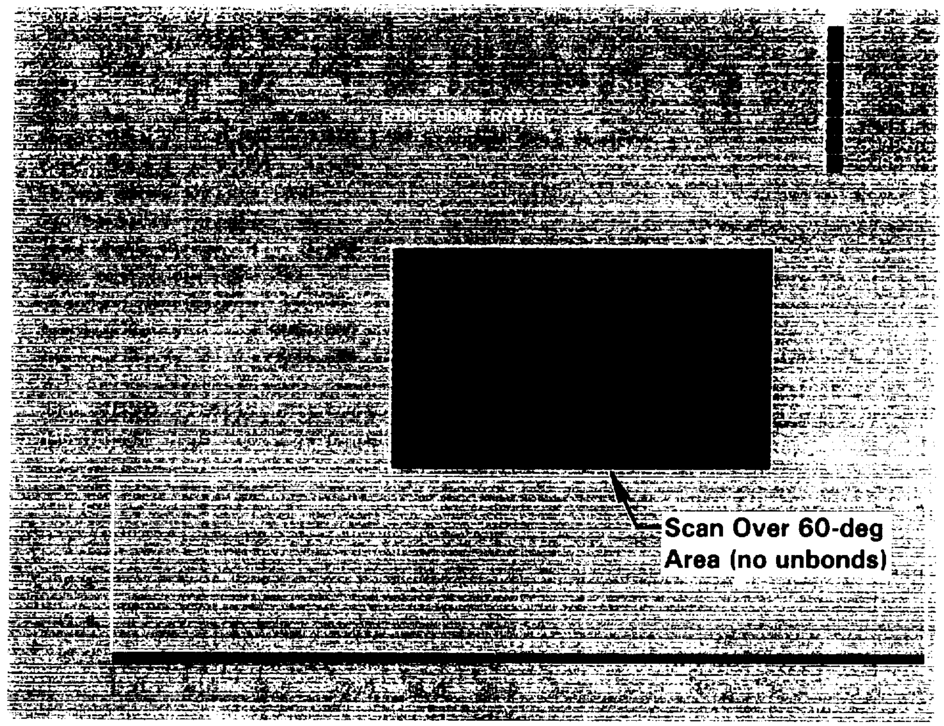
C-scan Presentation



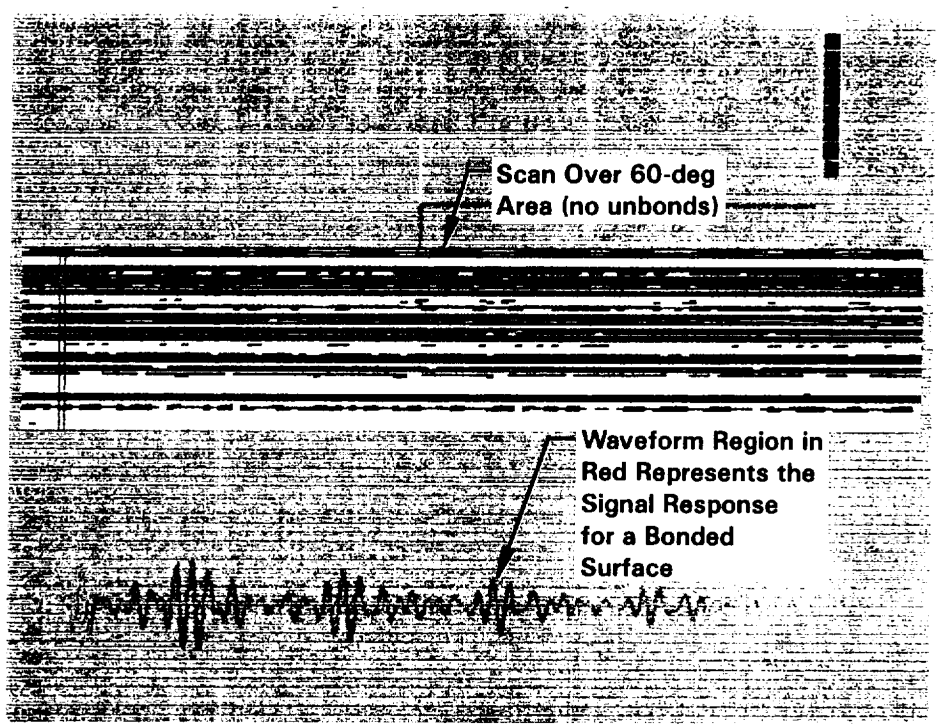
B-scan Presentation

Figure 23. Calibration-in Sequence--Scan Run No. 4

ORIGINAL PAGE IS
OF POOR QUALITY

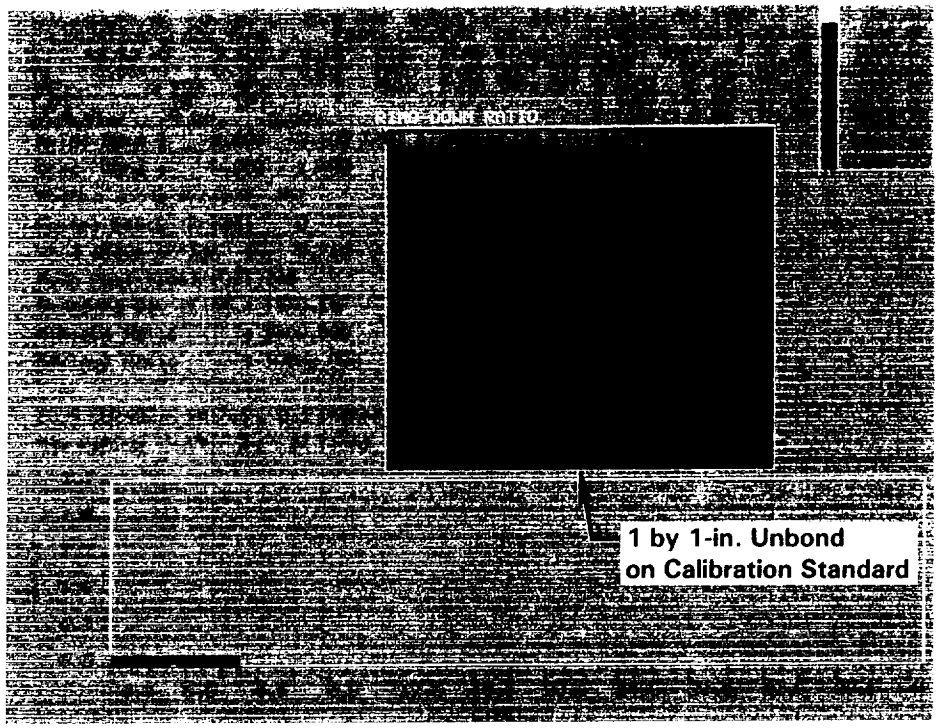


C-scan Presentation

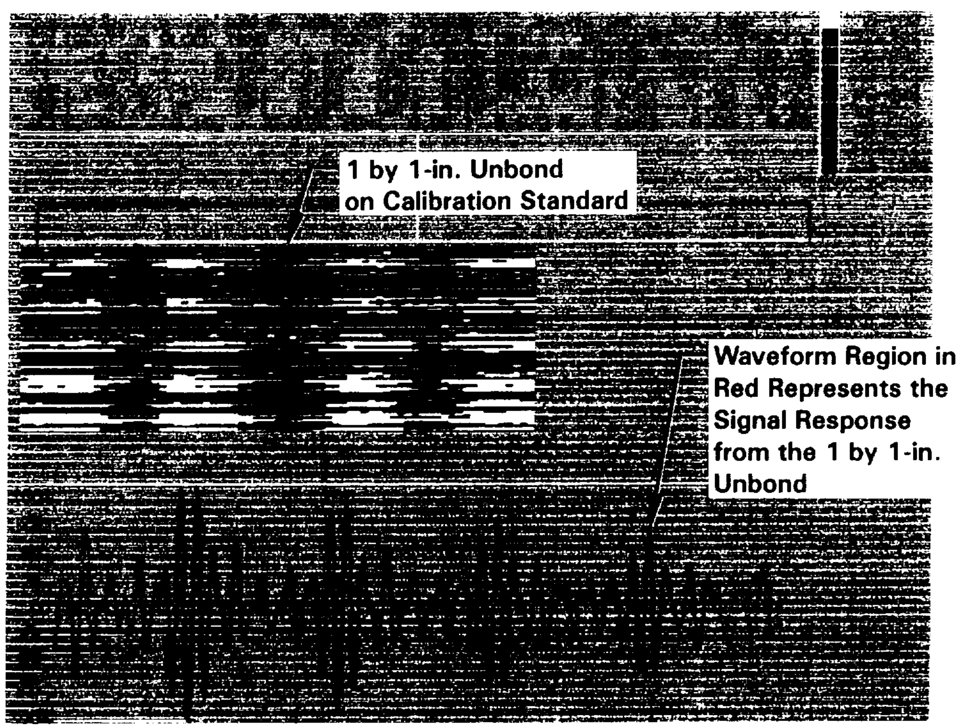


B-scan Presentation

Figure 24. Scanning Sequence--Scan Run No. 4



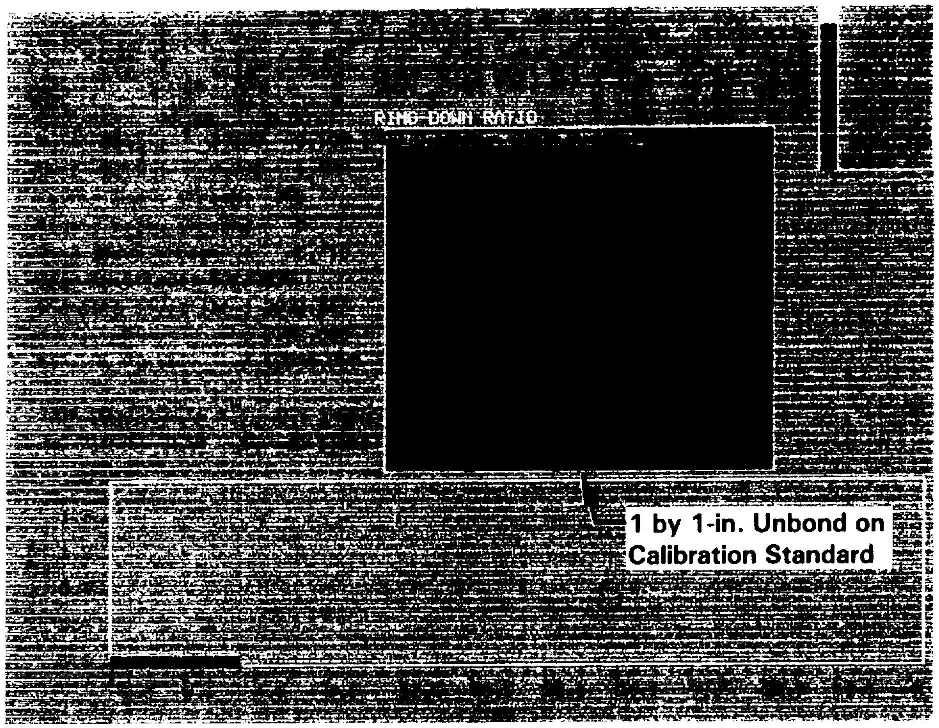
C-scan Presentation



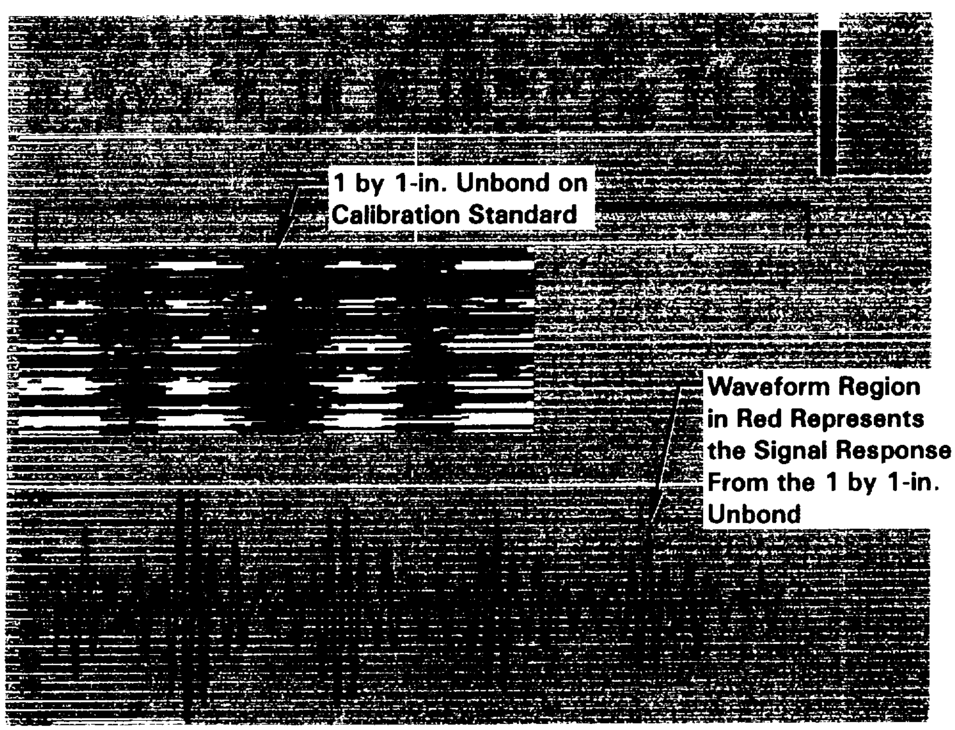
B-scan Presentation

Figure 25. Calibration-out Sequence--Scan Run No. 4

ORIGINAL PAGE IS
OF POOR QUALITY

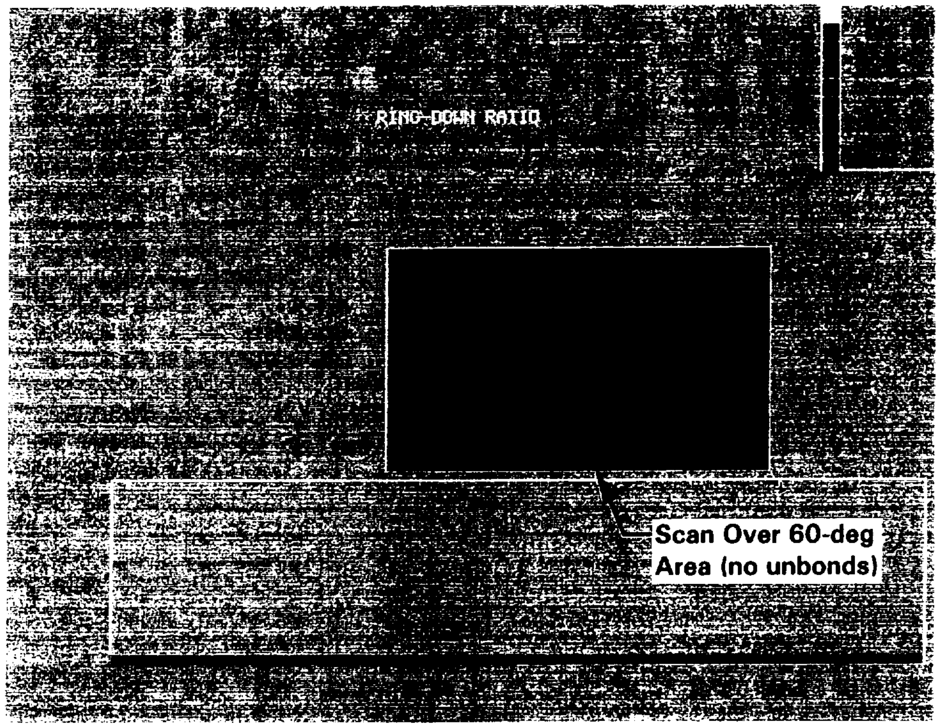


C-scan Presentation

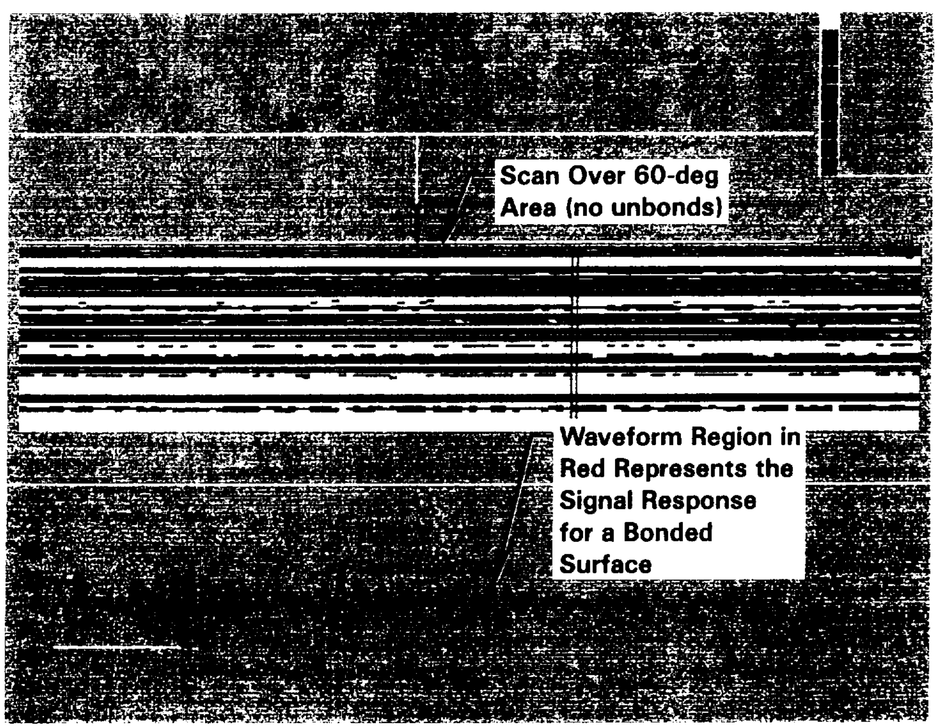


B-scan Presentation

Figure 26. Calibration-in Sequence--Scan Run No. 5

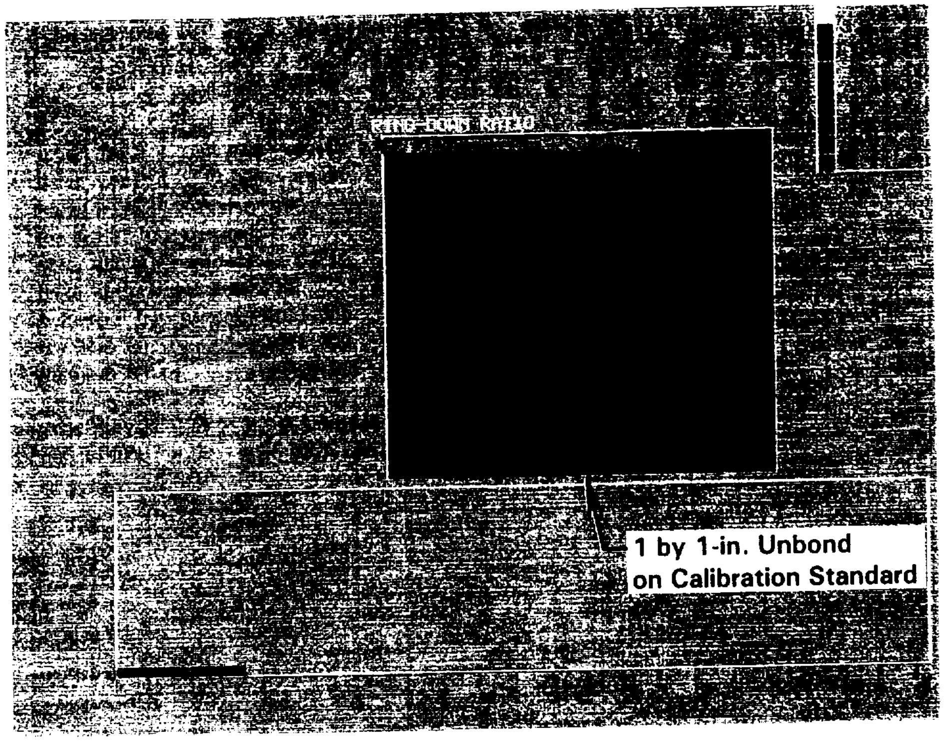


C-scan Presentation

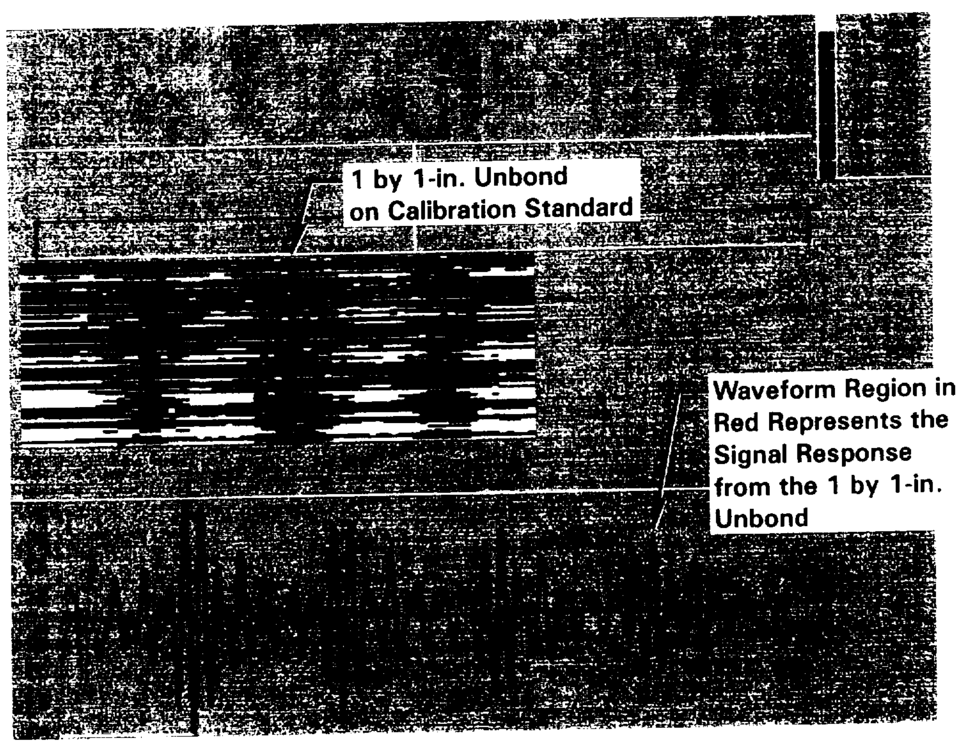


B-scan Presentation

Figure 27. Scanning Sequence--Scan Run No. 5



C-scan Presentation



B-scan Presentation

Figure 28. Calibration-out Sequence--Scan Run No. 5

7

APPLICABLE DOCUMENTS

Document No.	Title
CPW1-3600	Prime Equipment Contract End Item (CEI) Detail Specifications
CDW2-3452	Performance, Design, and Verification Requirements, Case-to-Insulation Bondline Inspection Kit, Ultrasonic Model Designator, C77-0479
CTP-0085	Qualification Plan for the Ultrasonic Inspection of the RSRM Field Joint Capture Feature Case/Insulation Bondline Utilizing the Thiokol Ultrasonic RSRM Bondline Inspection System
CTP-0100	Qualification Test Plan for the Generic System Components of The Thiokol Ultrasonic RSRM Bondline Inspection System (URBIS)
NHB 6000.1	NASA Requirements for Packaging, Handling and Transportation (for aeronautical and space systems, equipment, and associated components)
TWR-18894	Generic System Components of the RSRM Case-to-Insulation Bondline Inspection System Final Test Report
Military Standards	
MIL-STD-45662	Calibration System Requirements
Drawing No.	
2U129702	NDE Calibration Kit, SRM
2U129431	SRM PLI/Case UT Inspection Tool Arrangement

DISTRIBUTION

Recipient	No. of Copies	Mail Stop
M. Cook	4	L71
N. Black	1	L71
G. Paul	1	L71
G. Lebaron	1	L72
B. Bruce	1	E06
D. Marsh	1	E63
L. Allred	1	L72
H. Reed	1	827
M. Martersteck	1	827
P. Karner	1	827
D. Anderson	1	827
G. Donikowski	1	877
K. Sanofsky	1	851
F. Duersch	1	851
D. Noble	1	THI-711(KSC)
R. Papasian	45	E05
Print Crib	5	282
Data Management	5	L23E